Agriculture
Canada

RESEARCH BRANCH REPORT

1987

RAPPORT DE LA DIRECTION GÉNÉRALE DE LA RECHERCHE

Canada

Research Branch Report

1987

Rapport de la Direction générale de la recherche

RESEARCH BRANCH
DIRECTION GÉNÉRALE DE LA RECHERCHE

AGRICULTURE CANADA

Agriculture Canada Publication 5252
available from
Communications Branch, Agriculture Canada
Ottawa, K1A 0C7

©Minister of Supply and Services Canada 1988
Cat. No. A51-1/1987 ISBN 0-662-56095-7
Printed 1988 2M-10:88

Agriculture Canada Publication 5252
On peut en obtenir des exemplaires à la
Direction générale des communications
Agriculture Canada, Ottawa K1A 0C7

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N° de cat. A51-1/1987 ISBN 0-662-56095-7
Impression 1988 2M-10:88

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FOREWORD

1987 marks the beginning of the second century of activity by the Research Branch of Agriculture Canada. As this new century is ushered in, we note a number of important changes within the branch that will enable it to respond more effectively to the evolving needs of a modern world. Perhaps the most evident change is the reorganization of the regions: a reduction from five to three, with the regional headquarters now relocated to Research Branch Headquarters in Ottawa. This reorganization will facilitate communication among senior management, so important to the branch now with increasing pressures on all government departments for enhanced efficiency and greater accountability.

The *Research Branch Report* provides an annual summary of achievements throughout the branch. During 1987, the regions and research establishments of the branch effectively contributed to departmental objectives aimed at enhancing growth, stability, and competitiveness in the agri-food sector. Results are reported in both scientific and extension-type papers. Those for 1987 are listed at the end of each establishment's report. Information is passed on to producers and food processors through various provincial committees and technology transfer mechanisms.

The Eastern, Central, and Western regions of the Research Branch include 33 major establishments, 13 experimental farms, and several smaller units. Each one carries out research with national and regional objectives while developing technology that is pertinent to the specific area where it is located. The Eastern Region has responsibility for the establishments in Ontario, Quebec, and the Atlantic Provinces. The Central Region, consisting of six research centres on the Central Experimental Farm in Ottawa, combines research on national programs with special services to regional establishments and the public. The Western Region has 12 major establishments located in the four western provinces.

The Priorities and Strategies Directorate, located at Research Branch Headquarters in Ottawa, has six principal functions. These are Finance, Industry Relations, Management Services, Policy and Client Relations, Program Coordination, and Research Program Service.

Research programs in the branch are developed in response to the needs of the agri-food industry, which are determined through the Canadian Agricultural Services Coordinating Committee (CASCC) and by consultations at all levels of the agri-food sector. The branch is responsible for organization of the activities of CASCC and of the Canadian Agricultural Research Council (CARC).

Research programs encompass all components of the industry, including natural resources, animal and crop production, protection, food processing, nutrition, and food safety. As part of these programs, research is conducted with a view to enhancing utilization and marketability.

In 1987, the Research Branch had a budget of $221.5 million and a staff of 3481, of which 911 were research professionals.

The Research Branch cooperates with other branches of Agriculture Canada, with other federal departments, and with various agencies on activities related to the agri-food sector. In 1987, the Research Branch actively participated in the departmental restructuring toward commodity-based, market-oriented development strategies.

The Research Branch has ongoing science and technology exchanges with several countries, including 13 with whom Agriculture Canada has memoranda of understanding and another nine with whom there are other formal arrangements for exchange. Scientific and technical information and personnel are provided to development-assistance projects overseas, including the management and staffing of long-term development projects sponsored by the Canadian International Development Agency (CIDA).

This report documents the continuous efforts by Research Branch staff to deliver a broad and effective research program that benefits all sectors of the agri-food industry.

A.O. Olson
Assistant Deputy Minister, Research

AVANT-PROPOS

L'année 1987 marque le début du second siècle d'activités de la Direction générale de la recherche d'Agriculture Canada. Le début de ce nouveau siècle s'accompagne d'un certain nombre de changements importants au sein de la Direction générale, qui lui permettront de répondre plus efficacement aux nouveaux besoins du monde moderne. Un des changements les plus manifestes est peut-être la réorganisation des régions : leur nombre est passé de cinq à trois et leur administration a été relogée au siège de la Direction générale de la recherche à Ottawa. Cette réorganisation facilitera la communication entre les gestionnaires cadres, élément qui devient maintenant si important pour la Direction générale, car les pressions exercées sur tous les ministères pour améliorer l'efficacité et exercer une plus grande imputabilité se font de plus en plus fortes.

Le *Rapport de la Direction générale de la recherche* est un résumé annuel des réalisations de la Direction générale. En 1987, les régions et les centres de recherches de la Direction générale ont contribué de façon efficace à la réalisation des objectifs du Ministère qui étaient d'augmenter le taux de croissance, la stabilité et la compétitivité du secteur agro-alimentaire. Les résultats ont été publiés dans des articles scientifiques et de vulgarisation. La liste de ces articles pour 1987 se trouve à la fin du rapport de chacun des centres de recherches. L'information est communiquée aux producteurs et aux transformateurs d'aliments par divers comités provinciaux et par des mécanismes de transfert de technologie.

Les régions de l'Est, du Centre et de l'Ouest de la Direction générale de la recherche comptent 33 grands établissements, 13 fermes expérimentales et plusieurs unités plus petites. Chacun de ces établissements procède à des travaux de recherche qui poursuivent des objectifs nationaux et régionaux tout en développant une technologie adaptée à sa propre région. La Région de l'Est est responsable des établissements situés en Ontario, au Québec et dans les provinces de l'Atlantique. Celle du Centre, qui compte six centres de recherches à la Ferme expérimentale centrale à Ottawa fait des recherches sur les programmes nationaux et assurent des services spéciaux aux établissements régionaux et au public. La Région de l'Ouest compte 12 grands établissements dans les quatre provinces de l'Ouest.

La Direction des priorités et stratégies, logée au siège de la Direction générale de la recherche à Ottawa, a six composantes principales, notamment la Finance, les Relations industrielles, les Services de la gestion, le Politique et les relations avec le client, la Coordination du programme et le Service aux programmes de recherche.

Les programmes de recherche de la Direction générale sont conçus pour satisfaire aux besoins du secteur agro-alimentaire, qui sont évalués par le Comité de coordination des services agricoles canadiens (CCSAC) et par des consultations auprès de tous les segments du secteur agro-alimentaire. La Direction générale se charge de l'organisation des activités du CCSAC et du Conseil de recherche agricole du Canada (CRAC).

Les programmes de recherche couvrent tous les segments du secteur, soit les ressources naturelles, la production animale et végétale, la protection, la nutrition, la transformation et l'innocuité des aliments. La recherche conduite au sein de ces programmes vise à améliorer l'utilisation et la commercialisation des produits.

En 1987, la Direction générale de la recherche disposait d'un budget de 221,5 millions de dollars et d'un effectif de 3 481 membres dont 911 chercheurs.

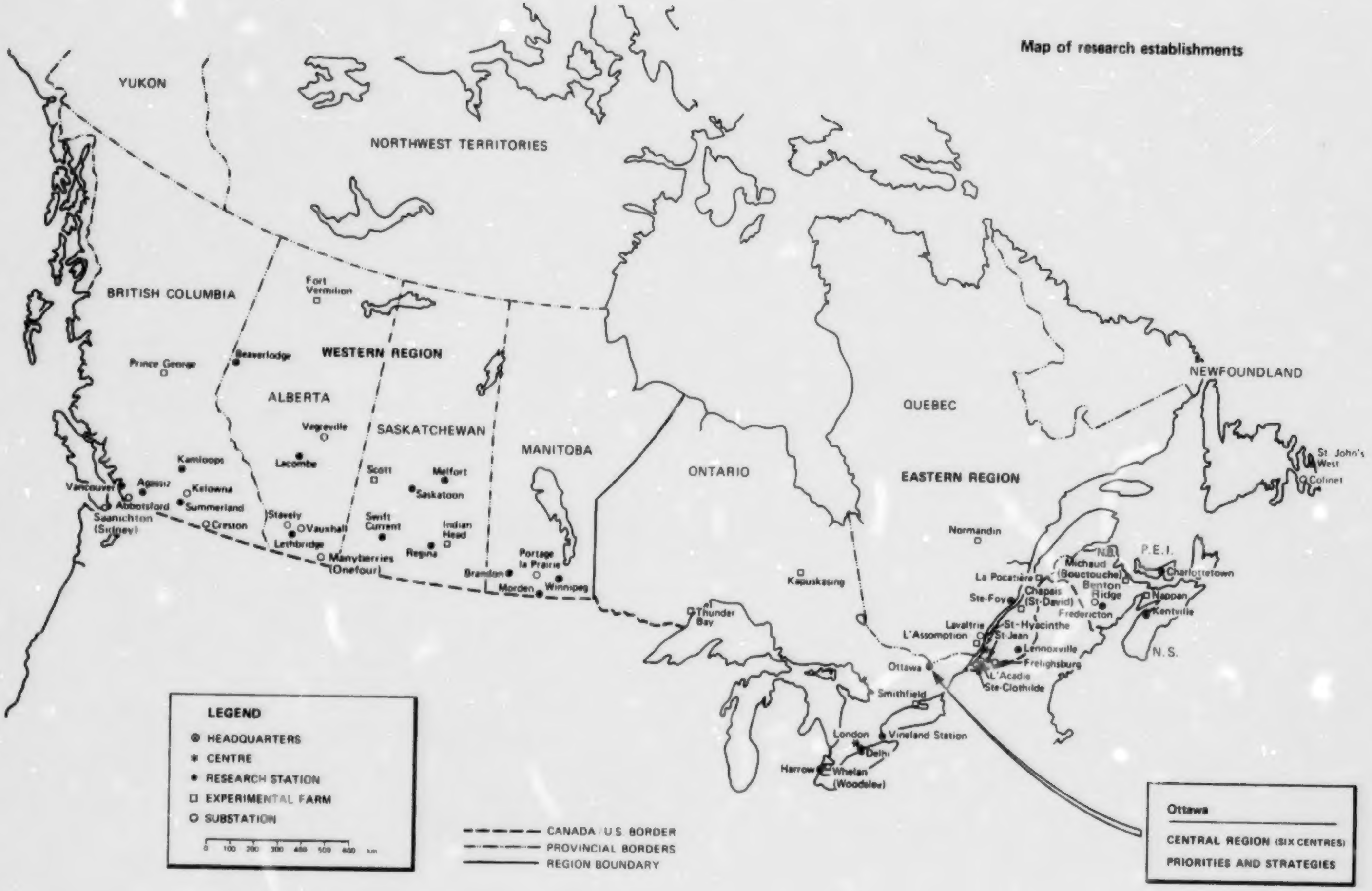
La Direction générale collabore avec d'autres directions générales d'Agriculture Canada, d'autres ministères fédéraux et divers organismes à des travaux intéressant le secteur agro-alimentaire. En 1987, elle a participé activement à la restructuration du Ministère en vue de l'implantation de stratégies de développement sectoriel axé sur les marchés.

La Direction générale de la recherche procède, en permanence, à des échanges scientifiques et technologiques avec plusieurs pays. Agriculture Canada a conclu des protocoles d'entente avec 13 pays et a pris des arrangements pour des échanges officiels avec neuf autres pays. La Direction générale fournit l'information et le personnel scientifiques et techniques nécessaires aux projets d'aide au développement outre-mer et participe à la gestion et à la dotation des projets de développement à long terme parrainés par l'Agence canadienne de développement international (ACDI).

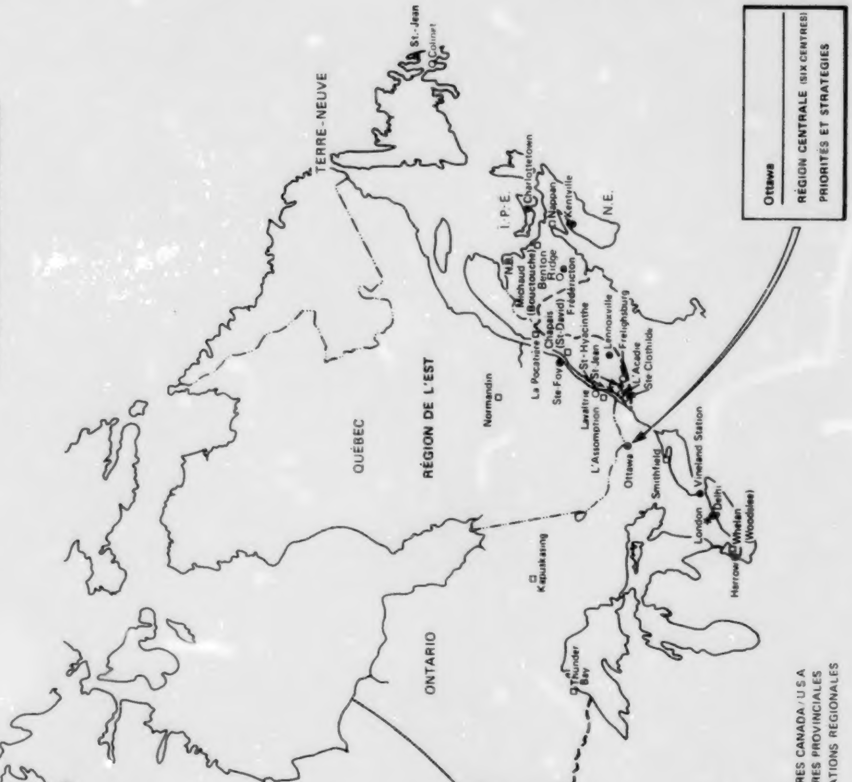
Le présent rapport souligne les efforts constants consacrés par le personnel de la Direction générale de la recherche à la réalisation d'un programme de recherche vaste et efficace qui profite à tous les segments du secteur agro-alimentaire.

A.O. Olson
Sous-ministre adjoint à la Recherche

Map of research establishments

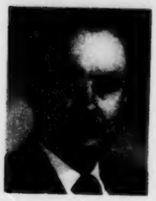

YUKON
NORTHWEST TERRITORIES
BRITISH COLUMBIA
ALBERTA
SASKATCHEWAN
MANITOBA
ONTARIO
QUEBEC
NEWFOUNDLAND
P.E.I.
N.B.
N.S.
WESTERN REGION
EASTERN REGION
Prince George
Beaverlodge
Fort Vermilion
Vegreville
Lacombe
Kamloops
Agassiz
Kelowna
Summerland
Vancouver
Abbotsford
Saanichton (Sidney)
Creston
Stavely
Vauxhall
Lethbridge
Manyberries (Onefour)
Scott
Melfort
Saskatoon
Swift Current
Indian Head
Regina
Portage la Prairie
Brandon
Morden
Winnipeg
Thunder Bay
Kapuskasing
Normandin
La Pocatière
Michaud (Bouctouche)
Charlottetown
Ste-Foy
Chapais (St-David)
Benton Ridge
Fredericton
Nappan
Kentville
Lavaltrie
St-Hyacinthe
L'Assomption
St-Jean
Lennoxville
Ottawa
Frelighsburg
L'Acadie
Ste-Clothilde
Smithfield
Vineland Station
London
Delhi
Harrow
Whelan (Woodslee)
St John's West
Colinet
LEGEND
⊗ HEADQUARTERS
* CENTRE
• RESEARCH STATION
□ EXPERIMENTAL FARM
○ SUBSTATION
0 100 200 300 400 500 600 km
CANADA/U.S. BORDER
PROVINCIAL BORDERS
REGION BOUNDARY
Ottawa
CENTRAL REGION (SIX CENTRES)
PRIORITIES AND STRATEGIES

Carte des établissements de recherches


YUKON
TERRITOIRES DU NORD-OUEST
COLOMBIE-BRITANNIQUE
ALBERTA
SASKATCHEWAN
MANITOBA
ONTARIO
QUÉBEC
TERRE-NEUVE
RÉGION DE L'OUEST
RÉGION DE L'EST
N.B.
I.-P.-É.
N.É.
Prince George
Kamloops
Agassiz
Kelowna
Summerland
Vancouver
Abbotsford
Saanichton (Sidney)
Creston
Beaverlodge
Fort Vermilion
Vegreville
Lacombe
Stavely
Lethbridge
Vauxhall
Manyberries (Onefour)
Scott
Swift Current
Saskatoon
Melfort
Regina
Indian Head
Brandon
Morden
Portage-la-Prairie
Winnipeg
Thunder Bay
Kapuskasing
Harrow
Delhi
Woodslee
London
Vineland Station
Smithfield
Ottawa
L'Assomption
Normandin
Lavaltrie
Ste Foy
La Pocatière
Chapais
(St-David)
St-Hyacinthe
St-Jean
Lennoxville
L'Acadie
Frelighsburg
Ste Clothilde
Fredericton
Benton Ridge
Richibucto (Bouctouche)
Charlottetown
Nappan
Kentville
St.-Jean
Colinet
Ottawa
RÉGION CENTRALE (SIX CENTRES)
PRIORITÉS ET STRATÉGIES
LÉGENDE
⊛ ADMINISTRATION
✱ CENTRE
● STATION DE RECHERCHES
☐ FERME EXPÉRIMENTALE
○ SOUS-STATION
0 100 200 300 400 500 600 km
FRONTIÈRES CANADA / U.S.A.
FRONTIÈRES PROVINCIALES
DÉLIMITATIONS RÉGIONALES

A.O. Olson

I.A. de la Roche



Y. Martel

J.J. Cartier

W.L. Pelton

J.R. Lessard

M. Gerrie

Headquarters
Administration centrale

BRANCH EXECUTIVE
HAUTE DIRECTION

Assistant Deputy Minister, Research *Sous-ministre adjoint à la Recherche*	A.O. Olson, B.Sc., Ph.D.
Directors General *Directeurs généraux*	
Priorities and Strategies *Priorités et des stratégies*	I.A. de la Roche, B.Sc., M.S., Ph.D.
Eastern Region *Région de l'Est*	Y. Martel, B.A., B.Sc.(Agr.), Ph.D.
Central Region *Région centrale*	J.J. Cartier, B.A., B.Sc., Ph.D.
Western Region *Région de l'Ouest*	W.L. Pelton, B.S.A., M.S.A., Ph.D.
Special Adviser *Conseiller spécial*	
Executive Assistant *Adjoint exécutif*	J.R. Lessard, B.A., B.Sc., M.S., Ph.D.
Branch Personnel Management *Gestion du personnel de la Direction générale*	
Manager *Gestionnaire*	M. Gerrie[1]
Departures *Départs*	
R.L. Halstead, B.S.A., Ph.D. Retired March 1987 *Retraité en mars 1987*	Special Adviser to ADM *Conseiller spécial du SMA*
J.-J. Jasmin, B.Sc.(Agr.), M.Sc. Retired March 1987 *Retraité en mars 1987*	Director General, Quebec Region *Directeur général, Région du Québec*
S.C. Thompson, B.Sc., M.S.A., Ph.D. Transferred to Food Production and Inspection Branch, April 1987 *Muté à la Direction générale de la production et de l'inspection des aliments*	Director General, Pacific Region *Directeur général, Région du Pacifique*

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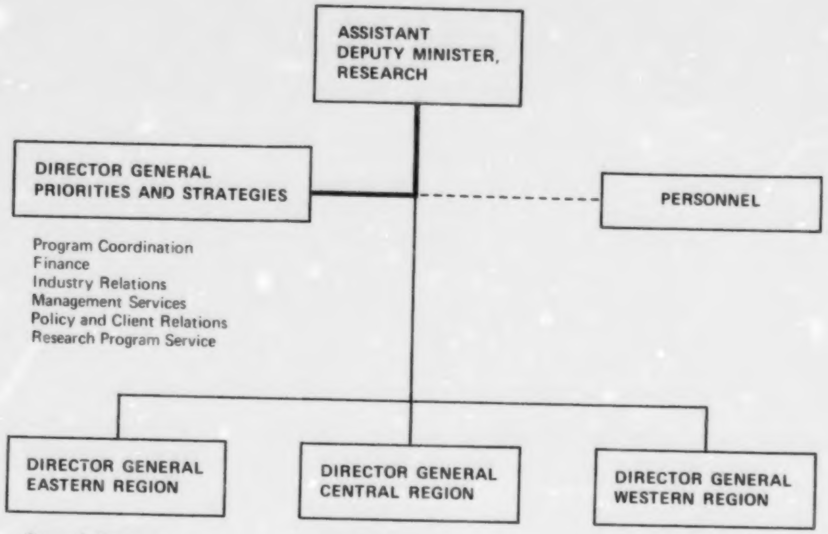
[1] **Personnel Administration Branch** *Direction générale de l'administration du personnel.*

ORGANIZATION OF THE RESEARCH BRANCH


ASSISTANT DEPUTY MINISTER, RESEARCH

DIRECTOR GENERAL PRIORITIES AND STRATEGIES

PERSONNEL

Program Coordination
Finance
Industry Relations
Management Services
Policy and Client Relations
Research Program Service

DIRECTOR GENERAL EASTERN REGION

DIRECTOR GENERAL CENTRAL REGION

DIRECTOR GENERAL WESTERN REGION

Research Stations

- St. John's West, Nfld.
  - Colinet, Nfld.
- Charlottetown, P.E.I.
- Kentville, N.S.
  - Nappan, N.S.
- Fredericton, N.B.
  - Benton Ridge, N.B.
  - Michaud (Bouctouche), N.B.
- Lennoxville, Que.
- Sainte-Foy, Que.
  - La Pocatière, Que.
  - Normandin, Que.
  - Chapais (Saint-David), Que.
- Saint-Jean, Que.
  - Frelighsburg, Que.
  - L'Acadie, Que.
  - L'Assomption, Que.
  - Lavaltrie, Que.
  - Sainte-Clothilde, Que.
- Delhi, Ont.
- Harrow, Ont.
  - Whelan (Woodslee), Ont.
- Vineland Station, Ont.
  - Smithfield, Ont.

Experimental Farm

- Kapuskasing, Ont.
  - Thunder Bay, Ont.

Research Centres

- Food, Sainte-Hyacinthe, Que.
- London, Ont.

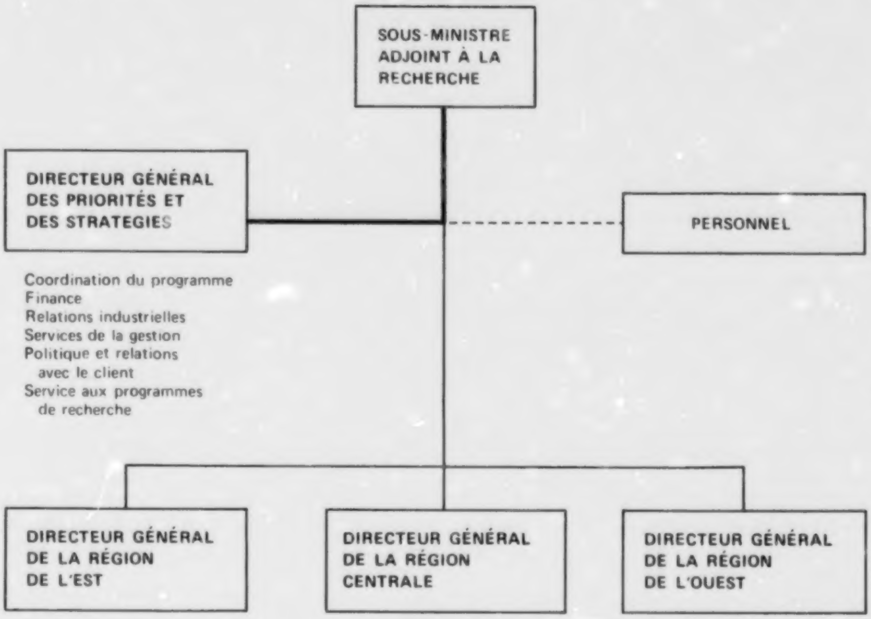
Research Centres

- Animal
- Biosystematics
- Engineering and Statistical
- Food
- Land Resource
- Plant

Research Stations

- Brandon, Man.
- Morden, Man.
  - Portage la Prairie, Man.
- Winnipeg, Man.
- Melfort, Sask.
- Regina, Sask.
  - Indian Head, Sask.
- Saskatoon, Sask.
  - Scott, Sask.
- Swift Current, Sask.
- Beaverlodge, Alta.
  - Fort Vermilion, Alta.
- Lacombe, Alta.
  - Vegreville, Alta.
- Lethbridge, Alta.
  - Manyberries (Onefour), Alta.
  - Stavely, Alta.
  - Vauxhall, Alta.
- Agassiz, B.C.
  - Abbotsford, B.C.
  - Saanichton Research and Plant Quarantine Station (Sidney), B.C.
- Kamloops, B.C.
  - Prince George, B.C.
- Summerland, B.C.
  - Creston, B.C.
  - Kelowna, B.C.
- Vancouver, B.C.

ORGANISATION DE LA DIRECTION GÉNÉRALE DE LA RECHERCHE


SOUS-MINISTRE ADJOINT À LA RECHERCHE
DIRECTEUR GÉNÉRAL DES PRIORITÉS ET DES STRATEGIES
PERSONNEL
DIRECTEUR GÉNÉRAL DE LA RÉGION DE L'EST
DIRECTEUR GÉNÉRAL DE LA RÉGION CENTRALE
DIRECTEUR GÉNÉRAL DE LA RÉGION DE L'OUEST

Coordination du programme
Finance
Relations industrielles
Services de la gestion
Politique et relations
  avec le client
Service aux programmes
  de recherche

Stations de recherches

Saint-Jean (T.-N.)
  Colinet (T.-N.)
Charlottetown (Î.-P.-É.)
Kentville (N.-É.)
  Nappan (N.-É.)
Frédéricton (N.-B.)
  Benton Ridge (N.-B.)
  Michaud
    (Bouctouche)(N.-B.)
Lennoxville (Québec)
Sainte-Foy (Québec)
  La Pocatière (Québec)
  Normandin (Québec)
  Chapais
    (Saint-David)(Québec)
Saint-Jean (Québec)
  Frelighsburg (Québec)
  L'Acadie (Québec)
  L'Assomption (Québec)
  Lavaltrie (Québec)
  Sainte-Clothilde (Québec)
Delhi (Ont.)
Harrow (Ont.)
  Whelan
    (Woodslee)(Ont.)
Vineland Station (Ont.)
  Smithfield (Ont.)

Ferme expérimentale

Kapuskasing (Ont.)
  Thunder Bay (Ont.)

Centres de recherches

Aliments
  (Saint-Hyacinthe)(Québec)
London (Ont.)

Centres de recherches

Aliments
Biosystématique
Phytotechniques
Technique et statistique
Terres
Zootechnie

Stations de recherches

Brandon (Man.)
Morden (Man.)
  Portage-la-Prairie (Man.)
Winnipeg (Man.)
Melfort (Sask.)
Regina (Sask.)
  Indian Head (Sask.)
Saskatoon (Sask.)
  Scott (Sask.)
Swift Current (Sask.)
Beaverlodge (Alb.)
  Fort Vermilion (Alb.)
Lacombe (Alb.)
  Végreville (Alb.)
Lethbridge (Alb.)
  Manyberries
    (Onefour)(Alb.)
  Stavely (Alb.)
  Vauxhall (Alb.)
Agassiz (C.-B.)
  Abbotsford (C.-B.)
  Station de recherches et
    de quarantaine des
    plantes de Saanichton
    (Sidney)(C.-B.)
Kamloops (C.-B.)
  Prince George (C.-B.)
Summerland (C.-B.)
  Creston (C.-B.)
  Kelowna (C.-B.)
Vancouver (C.-B.)

PROGRAM STRUCTURE OF THE RESEARCH BRANCH

Departmental objective

Agriculture Canada's objective is to promote the growth, stability, and competitiveness of the agri-food sector, by making available policies, programs, and services that are most appropriately provided by the federal government, so that the sector makes its maximum contribution to the economy.

Branch objective

The Research Branch's objective for the scientific research and development planning element is to maintain and improve the productivity of the agri-food sector through developing and transferring new knowledge and technology.

Objectives for branch planning sub-elements and sub-sub-elements

Management and administration. To provide the managerial, financial, personnel, and administrative services required for efficient management of the Research Branch.

1. Planning and program management
   To provide branch planning and program coordination in support of senior branch management.
2. Administrative services
   To provide support for branch management in financial, personnel, and any other administrative areas necessary for the efficient functioning of the branch.

Resource and research. To produce scientific and technical information and to develop technology that will assist the agri-food sector in managing and conserving the natural resources necessary for agricultural production, while increasing the level and efficiency of production, and that will assist other researchers in developing applied technology.

1. Land
   To provide accurate information about the quantity, quality, and location of Canada's land resource and to better understand the properties of soils, which affect agricultural productivity.
2. Water and climate
   To improve water management on Canadian soils in order to increase productivity and to monitor and preserve environmental quality within the constraints imposed by Canada's northern climate.
3. Energy and engineering
   To develop and adapt engineering technology that will optimize energy utilization and efficiency of production, storage, processing, and distribution of agricultural products.
4. Biological resources
   To provide accurate information about the quantity, quality, and location of Canada's biological resources (including vascular plants, insects, arachnids, nematodes, fungi, and bacteria) and to provide identification services that can be used as required to ensure agricultural productivity.
5. Biotechnology
   To assess, develop, and utilize technology in support of basic and applied agricultural research.
6. Protection
   To provide new, general, and basic research information on the protection of animals and crops from diseases, insects, and weeds.
7. Scientific support services
   To provide for all scientific researchers the statistical, graphic arts, publishing, and other general support services necessary to maintain the quality and quantity of output of research findings.

Animal research. To produce scientific and technical information and develop new technology that will assist the primary producer in increasing the quality and efficiency of the production of animals.

1. Beef
   To improve the efficiency of beef production and the quality of beef products in support of regional, domestic, and export market development.
2. Dairy
   To improve the efficiency of milk production for domestic and export market development.

3. Swine
   To improve the efficiency of pork production and the quality of pork and pork products in support of domestic and export market development.
4. Poultry
   To improve the efficiency of production of eggs and poultry meat and the quality of poultry products in support of domestic and export market development.
5. Other animals
   To increase the efficiency of production and quality of products from sheep, honey bees, fur bearers, and any other animals deemed to be of agricultural importance in support of domestic and export market development.

Crop research. To produce scientific and technical information and develop new technology that will assist the primary producer in increasing the quality and efficiency of the production of crops.

1. Cereals
   To increase the production efficiency, quality, and protection of cereal crops for domestic and export markets.
2. Oilseeds
   To increase the efficiency of production adaptability and the quality of oilseed crops and their products for domestic and export markets.
3. Forages
   To increase the efficiency of production adaptability and the quality of domestic forage crops in support of livestock production.
4. Field crops
   To increase the production efficiency, quality, and protection of field crops such as tobacco, field peas, buckwheat, and field beans.
5. Vegetables
   To increase the efficiency of production, protection, adaptability, and quality of vegetables for the domestic market, and of potatoes and seed potatoes for export.
6. Tree fruits and berries
   To increase the efficiency of production, protection, adaptability, and quality of tree fruits and berries for domestic and export markets.
7. Ornamentals
   To develop, test, and release high-quality ornamental plants that are adapted to Canada's climatic regions.

Food research. To produce scientific and technical information and develop technology that will assist the agri-food processing sector in increasing the efficiency and effectiveness of crop and animal commodity processing, while ensuring the safety and nutritional value of food.

1. Food processing, equipment, and products
   To develop new food-processing technology, to improve the efficiency and effectiveness of food-processing systems, and to develop and characterize new uses of products and ingredients from agricultural crops and animal products.
2. Food safety and nutrition
   To increase consumer safety from antinutritional and toxic constituents in food and to monitor and improve the nutritive value of agricultural products.
3. Storage
   To develop and apply processes and handling procedures for maintaining the quality of foods after crop harvest.

STRUCTURE DU PROGRAMME DE LA DIRECTION GÉNÉRALE DE LA RECHERCHE

Objectif du Ministère

L'objectif d'Agriculture Canada est de promouvoir la croissance, la stabilité et la compétitivité du secteur agro-alimentaire au moyen de politiques, de programmes et de services fournis par le gouvernement fédéral, de façon à assurer une contribution optimale de ce secteur à l'économie.

Objectifs de la Direction générale

L'élément planification de la recherche scientifique et du développement de la Direction générale de la recherche a pour objectif d'améliorer la productivité du secteur agro-alimentaire en mettant au point de nouvelles technologies et en diffusant les connaissances.

Objectifs des sous-divisions et des sous-sous-divisions de la planification

Gestion et administration. Fournir les services nécessaires dans les domaines de la gestion, des finances, du personnel et de l'administration afin d'assurer une gestion efficace de la Direction générale.

1. Gestion et planification des programmes
   Assurer la planification et la coordination des programmes de la Direction générale afin d'appuyer la Haute Direction.

2. Services administratifs
   Fournir un soutien à la Haute Direction dans les domaines des finances, du personnel et dans tout autre domaine administratif pour assurer le bon fonctionnement de la Direction générale.

Recherche sur les ressources. Mettre à la disposition du secteur agro-alimentaire des informations scientifiques et techniques et développer des technologies qui l'aideront à gérer et à conserver les ressources naturelles nécessaires à la production agricole tout en augmentant leur utilisation efficace : ces mêmes ressources doivent aider les chercheurs à mettre au point des technologies appliquées.

1. Terres
   Fournir des informations précises sur la quantité, la qualité et l'emplacement des ressources en terres du Canada et parvenir à une meilleure connaissance des propriétés des sols, qui influent sur la productivité agricole.

2. Eau et climat
   Améliorer la gestion des eaux sur les sols du Canada afin d'accroître la productivité et de contrôler et conserver la qualité de l'environnement, en tenant compte des contraintes imposées par le climat boréal du Canada.

3. Énergie et génie
   Développer et adapter une technologie pour optimiser le rendement énergétique et l'efficacité de la production, du stockage, de la transformation et de la distribution des produits agricoles.

4. Ressources biologiques
   Fournir des informations précises sur la quantité, la qualité et l'emplacement des ressources biologiques du Canada (notamment les plantes vasculaires, insectes, arachnides, nématodes, champignons et bactéries) et offrir des services d'identification sur demande pour assurer la productivité agricole.

5. Biotechnologie
   Évaluer, développer et appliquer une technologie à l'appui de la recherche agricole fondamentale et appliquée.

6. Protection
   Fournir les résultats généraux et fondamentaux sur la recherche dans le domaine de la protection des animaux et des récoltes contre les maladies, les insectes et les mauvaises herbes.

7. Services de soutien scientifique
   Fournir à tous les chercheurs des statistiques, des publications et tout autre service d'aide générale nécessaire au maintien de la qualité de la recherche et à l'accroissement de la productivité des opérations.

Recherche sur les animaux. Produire l'information scientifique et technique et élaborer une nouvelle technologie afin d'aider le producteur primaire à augmenter la qualité et l'efficacité de la production animale.

1. Bovins de boucherie
   Accroître l'efficacité de la production bovine et améliorer la qualité des produits pour les marchés régional, national et d'exportation.

2. Bovins laitiers
   Accroître l'efficacité de la production laitière pour les marchés national et d'exportation.

3. Porcs
   Accroître l'efficacité de la production porcine et améliorer la qualité des produits pour les marchés national et d'exportation.

4. Volaille
   Accroître l'efficacité de la production des oeufs et de la volaille et améliorer la qualité des produits avicoles pour les marchés national et d'exportation.

5. **Autres animaux**
Accroître l'efficacité de la production ovine, apicole, d'animaux à fourrure et de tous les autres animaux jugés importants pour l'agriculture, pour les marchés national et d'exportation.

Recherche sur les cultures. Produire de l'information scientifique et technique et élaborer une nouvelle technologie afin d'aider le producteur primaire à augmenter la qualité et l'efficacité de la production animale.

1. **Céréales**
Accroître l'efficacité, la qualité et la protection des cultures céréalières pour les marchés national et d'exportation.

2. **Oléagineux**
Accroître l'adaptabilité sur le plan productif et la qualité des oléagineux et de leurs produits pour les marchés national et d'exportation.

3. **Fourrages**
Accroître l'adaptabilité sur le plan productif et la qualité des cultures fourragères sur le plan national afin d'aider à la production du bétail.

4. **Grandes cultures**
Accroître l'efficacité de la production, la qualité et la protection des grandes cultures comme le tabac, le pois sec, le sarrasin et le haricot sec.

5. **Légumes**
Accroître l'efficacité de la production, la protection, l'adaptabilité et la qualité des légumes pour le marché national, et des pommes de terre et des pommes de terre de semence pour l'exportation.

6. **Fruits de verger et petits fruits**
Accroître l'efficacité de la production, la protection, l'adaptabilité et la qualité des arbres fruitiers et des baies afin d'augmenter les marchés national et d'exportation.

7. **Plantes ornementales**
Développer, tester et distribuer des plantes d'ornement de grande qualité qui soient adaptées aux différentes régions climatiques du Canada.

Recherches sur les aliments. Fournir l'information scientifique et technique et élaborer la technologie à l'appui du secteur de la transformation agro-alimentaire afin d'accroître l'efficacité et la rentabilité de la transformation des produits animaux et végétaux tout en assurant la salubrité et la valeur nutritive des aliments produits.

1. **Transformation des aliments, équipements et produits**
Élaborer de nouvelles techniques de transformation des produits alimentaires, accroître l'efficacité et la rentabilité des systèmes de transformation et élaborer et caractériser de nouvelles façons d'utiliser des produits et ingrédients provenant des cultures et des animaux.

2. **Innocuité des aliments et nutrition**
Accroître la protection des consommateurs contre les constituants alimentaires toxiques et néfastes sur le plan nutritif et d'assurer et rehausser la valeur nutritive des produits agricoles.

3. **Entreposage**
Développer et mettre en pratique des façons de procéder pour maintenir la haute qualité des aliments après la moisson.

Priorities and Strategies Directorate
Direction des priorités et des stratégies

I.A. de la Roche

J.E. Renaud

G.M. Weaver

I.M. Wood

D.F. Kirkland

Y. Bélanger

Director General *Directeur général* I.A. de la Roche, B.Sc., M.S., Ph.D.

Program Coordination *Coordination du programme*

Director General *Directeur général*	I.A. de la Roche, B.Sc., M.S., Ph.D.

Division Directors *Directeurs des divisions*

Finance *Finance*	J.E. Renaud
Industry Relations, acting *Relations industrielles, intérimaire*	G.M. Weaver, B.Sc., Ph.D.
Management Services *Services de la gestion*	I.M. Wood
Policy and Client Relations *Politique et relations avec le client*	D.F. Kirkland
Research Program Service *Service aux programmes de recherche*	Y. Bélanger, B.Sc.

PREFACE

The Priorities and Strategies Directorate (P&SD) is an essential component of branch management at Research Branch Headquarters in Ottawa, supporting the Assistant Deputy Minister, Research, in his roles as both branch head and corporate manager. Through consultation and advice P&SD assists in the coordination of research programs and in the development and implementation of branch and department policies. It is also called upon to assist in the analysis of government policies that have an impact upon the branch and the department. In performing these advisory duties, P&SD is responsible for preparing briefings, position papers, and correspondence relating to any of these topics.

During the year, P&SD has undergone several significant changes. The most evident has been a change in name from the Program Coordination Directorate. This reflects a change in both structure and intensity of activity as a result of centralization and rationalization of resources, both of which were initiated last year.

Program coordination remains an important activity of the directorate, planning national programs through analysis of operational plans, reviewing the effectiveness of these programs in reaching objectives, and determining their impact on the agri-food sector. It coordinates, at the national level, the scientifically based activities that result in the monitoring and delivery of programs at the regional level.

In 1987, the Policy and Client Relations Division was formed to provide a focal point for directing the policy initiatives undertaken by the branch. It is the principal contact on matters concerning research and development (R&D) with central agencies, other departments, countries, provinces, universities, and industry. It effects liaison between the Research Branch and other branches, departments, and agencies, leading to collaborative action on national (e.g., Economic Regional Development Agreement) and international (e.g., CIDA) matters.

Personnel management is provided through a colocated operations unit of Personnel Branch headed by the branch personnel manager for research. This group was involved in a number of important activities in 1987. Changes were made in the annual scientist appraisal and promotion process, a management profile was developed for research station directors, interbranch exchanges were initiated, and a human resource plan was completed which included a process for followup on a number of human resources issues. Under the Research Branch human resource development plan, the directorate provides training for potential managers.

Management Services Division, Finance Division, and Research Program Service have been incorporated into the newly created Priorities and Strategies Directorate. Also, in order to respond to the requirement for increased involvement of industry in both the direction and funding of research, the Industry Relations Division has been established.

Thus, the P&SD now consists of the director general, five division directors and their support staff, six coordinators, and several special advisers. The coordinators and special advisers are senior professionals within their specific disciplines. Jointly, they are responsible for evaluating program content and direction and for providing guidance from a national perspective within specific program areas. There are coordinators for animal production, crop production (grains and oilseeds), crop production (horticulture and special crops), food, natural resources, and protection.

I.A. de la Roche
Director General

PRÉFACE

La Direction des priorités et stratégies (DPS) est une composante essentielle de l'administration au siège de la Direction générale à Ottawa, qui aide le Sous-ministre adjoint à la Recherche à assumer son rôle de chef de la Direction générale et de cadre de la gestion intégrée. Par des consultations et des conseils, la Direction collabore à la coordination des programmes de recherche et au développement, et à la mise en oeuvre des politiques de la Direction générale et du Ministère. Elle est également appelée à participer à l'analyse des politiques gouvernementales qui ont des incidences sur la Direction générale et le Ministère. Dans ses fonctions de conseillère, la Direction doit préparer des notes d'information, des exposés de principe et la correspondance connexe à ces sujets.

Durant l'année, la Direction a subi plusieurs modifications appréciables; elle a, entre autres, changé de nom : elle s'appelait antérieurement Direction de la coordination des programmes. Cette décision traduit un changement tant de la structure que de l'intensité des activités qui ont résulté de la centralisation et de la rationalisation des ressources entreprises toutes deux l'an dernier.

La coordination du programme demeure une des principales activités de la Direction, qui planifie les programmes nationaux par l'analyse des plans d'opérations, évalue le degré de réalisation des objectifs par ces programmes et détermine les répercussions de ces derniers sur le secteur agro-alimentaire. Elle coordonne, à l'échelle nationale, les activités axées sur la science qui aboutissent à la surveillance et à l'exécution de programmes de portée régionale.

En 1987, on a créé la Division du politique et des relations avec le client qui servira de centre d'orientation des programmes d'action entrepris par la Direction générale. C'est le principal point de contact sur des questions touchant à la recherche et au développement (R et D) avec les organismes centraux, d'autres ministères, d'autres pays, les provinces, les universités et le secteur privé. Elle assure la liaison entre la Direction générale de la recherche et d'autres directions générales, d'autres ministères et organismes, établissant ainsi une collaboration dans des activités nationales (ex. Entente de développement économique et régional) et internationales (ex. ACDI).

L'administration du personnel est assurée par une unité des opérations de la Direction générale du personnel logée au siège de la Direction générale de la recherche et dirigée par le gestionnaire du personnel de la Direction générale de la recherche. Ce groupe a participé à un certain nombre d'activités importantes en 1987. On a apporté des changements aux mécanismes d'évaluation annuelle et de promotion des chercheurs; on a tracé un profil du gestionnaire à l'intention des directeurs des stations de recherches; on a entrepris des échanges interdirections générales et on a préparé un plan de gestion des ressources humaines qui donne une méthode de suivi pour un certain nombre de questions portant sur les ressources humaines. Selon les prévisions du Plan de développement des ressources humaines de la Direction générale de la recherche, la Direction assure la formation des futurs gestionnaires.

La Division des services de la gestion, la Division de la finance et le Service aux programmes de recherche ont été incorporés à la Direction des priorités et stratégies nouvellement formée. De plus, en raison de la nécessité d'engager davantage le secteur privé dans l'orientation et le financement de la recherche, on a créé la Division des relations industrielles.

Ainsi, la Direction des priorités et stratégies compte maintenant un directeur général, cinq directeurs de divisions et leur personnel de soutien, six coordonnateurs et plusieurs conseillers spéciaux. Les coordonnateurs et les conseillers spéciaux sont des professionnels cadres dans leurs disciplines respectives. Ils sont conjointement chargés d'évaluer la teneur et la direction des programmes, et d'assurer une orientation, dans une perspective nationale, aux programmes spécifiques. Il y a un coordonnateur pour chacun des domaines de recherche suivants : la production animale, la production végétale (céréales et oléagineux), la production végétale (horticulture et cultures spéciales), les aliments, les ressources naturelles et la protection.

I.A. de la Roche
Directeur général

Program Coordination, Ottawa, Ontario

PROFESSIONAL STAFF

I.A. de la Roche, B.Sc., M.S., Ph.D.	Director General

Program Coordinators

L.M. Benzing-Purdie, B.Sc., M.Sc., Ph.D.	Natural resources, acting
R. Bouchard, B.A., B.S.A., M.Sc., Ph.D.	Animal production
B.B. Chubey, B.S.A., M.Sc., Ph.D.	Special Adviser, Crop production
R. Hironaka, B.Sc., M.Sc., Ph.D.	Special Adviser, Animal production
E. Larmond, B.Sc.	Food
G.A. Neish, B.Sc., Ph.D.	Protection, acting
P.W. Perrin, B.Sc., Ph.D.	Special Adviser, Food
W.J. Saidak, B.S.A., M.S., Ph.D., F.W.S.S.A.	Crop production – grains and oilseeds
C.B. Willis, B.Sc.(Agr.), Ph.D., F.A.I.C.	Crop Production – horticulture and special crops

Departure

J. Nowland, B.A., M.Sc. Seconded to Land Resource Research Centre, July 1987	Program Coordinator, Natural resources

INTRODUCTION

Program coordinators and special advisers report directly to the Director General, Priorities and Strategies Directorate. In addition to providing a national perspective in advising on the direction of research programs across the branch, coordinators and advisers provide scientific expertise and advice on policy issues to the branch head as well as to the Deputy Minister and the Minister. These individuals often provide scientific expertise to international delegations, play leadership roles in Canada committees and expert committees of the Canadian Agricultural Services Coordinating Committee (CASCC), act as liaison between the branch and its clients, and provide the perspective of the scientist–manager to such activities as program rationalization, human resource planning, scientist and manager appraisals, branch restructuring, and resource allocation. Special advisers are normally seconded from establishments for periods of 1–2 years and act in a role that is complementary to that of the coordinators.

Specific activities for 1987 in which Program Coordination was involved included the development of a current human resource management plan for the Research Branch. This was approved by Branch Management Committee (BMC) and the recommendations are being implemented. Coordinators collaborated with Audit and Evaluation Branch in the preparation of several research program evaluations during 1987. Members of the group also participated in the development of an industry relations policy. The resulting report and recommendations outlined several avenues for increased industry involvement. A major outcome was the establishment of the Industry Relations Office.

I.A. de la Roche
Director General

CROP PRODUCTION

Input to policy, planning, and program development

The directorate coordinated the preparation of proposed actions by the Research Branch in response to recommendations to address priority constraints and opportunities to increase access to markets as identified by departmental teams for the Horticulture and Special Crops sectors. A discussion paper on the changing research environment was prepared as background for industry consultations done with the grains and oilseeds sector.

A committee that included directorate personnel assessed and recommended on respective roles and responsibilities of the Delhi Research Station and the Ontario Ministry of Agriculture and Food (OMAF) horticultural experiment station at Simcoe. The recommendations were subsequently confirmed in a Memorandum of Understanding between the branch and OMAF.

Appropriate goals for the crops research programs were developed and integrated into the Branch Head Plan and appropriate research coordination goals were developed for the Priorities and Strategies Directorate work plan. Significant research accomplishments and deviations from plans were documented on a quarterly basis.

Research Branch strategies for crop commodities were identified, in collaboration with a branch task force, preparatory to consultations with provinces and industry on an agricultural research and technology transfer strategy for Canada. In addition, changes, both implemented and planned, to research programs were identified and integrated into proposals for action as follow up to the strategy exercise.

Interbranch and interdepartmental activities

Research Branch was represented on the National Research Council Committee on Industrial Research Assistance Program (IRAP), which evaluates and recommends on proposals for the IRAP funding, on the departmental Canadian Agricultural Market Development Initiative (CAMDI) Advisory Board, which allocates funds to projects having the objective of improving the market potential of Canadian agricultural products, on the departmental New Crop Development Fund Advisory Board, which allocates funds to projects having the objective of evaluating the potential of new crops for Canadian production, and on the departmental Plant Protection Advisory Committee and interbranch Committee on Alternate Crops. Representation was also provided on the 2,4-D Steering Committee, which led to an economic assessment of the benefits of 2,4-D use in Canada.

In collaboration with Food Production and Inspection Branch, the transfer from the department to the private sector of responsibility for the multiplication of Foundation and Certified seed of forage crop varieties developed by the branch was successfully negotiated.

Extramural activities

Relations with the seed industry were maintained through membership in the Canadian Seed Growers' Association and in the SeCan Association, as well as by frequent interactions with the Canadian Seed Trade Association. A similar function was provided to the grains and oilseeds sector through committee membership in the Canada Grains Council and the Brewing and Malting Barley Research Institute.

Consultations on research needs and priorities were organized and held with representatives of the apple, tender fruit, floriculture, and nursery industries, and the directorate participated with other branches of Agriculture Canada in general discussions of industry needs and government services.

Directorate personnel cooperated with the Canadian Horticultural Council in restructuring and publishing a report on horticultural research done at all federal and provincial government establishments and at universities in Canada. In addition, the branch was represented on committees for asparagus and potato chip research programs supported by funds from industry and remission of duties on products imported into Canada from the United States.

Consultation, advice, and leadership were provided in the crops area at the national level through representation on the Canada Committee on Crop Production Services as well as on the Expert Committees on Horticulture, Weeds, Plant Gene Resources, Pesticide Use in Agriculture, and Grains and Oilseeds.

ANIMAL PRODUCTION

Input to policy, planning, and program development

Sheep and dairy cattle research was rationalized in line with recommendations of the external review committees. The numbers of animals in the programs were reduced substantially because of diminished program requirements and greater industry involvement in genetic improvement. The program will focus on improving the long-term marketability of animal products. Centres to take lead roles in commodity and discipline research have been identified. The role of coordination was strengthened by secondment of a senior scientist with a wide knowledge of animal agriculture.

A major contribution was made to developing the working papers on *Canadian agricultural research and technology transfer: Planning for the future*. These documents rationalize research by the department for the present and into the 21st century to meet the challenges and opportunities of the agricultural industry.

Interbranch and intrabranch activities

New initiatives have been developed to enhance cooperation with Agriculture development Branch and industry in assessing data from the record of performance program. Assistance was provided to Policy Branch and Audit and Evaluation Branch to develop recommendations and to evaluate animal research programs. Animal Coordination coordinated the preparation of the branch publication *Progress in research*. Representation was made to the Canadian Council of Animal Care, and manuscripts on codes of practice for the care and handling of animals were reviewed. Animal Coordination provided leadership in an interbranch initiative to examine departmental policy on animal welfare issues.

External activities

Cooperation and consultation between Research Branch and producer groups were enhanced by meeting with the Dairy Farmers of Canada, the Canada Sheep Council, the Canada Pork Council, the Canadian Cattlemen's Association, the Canadian Association of Animal Breeders, and the Canadian Feed Industry Association.

Visits were made to several universities in Canada and the USA to discuss research priorities and to initiate complementary research efforts.

Animal Coordination formed part of the team to the tetrapartite meeting of heads of research in Canada, USA, Britain, and France.

NATURAL RESOURCES

Input to policy, planning, and program development

Contributions were made to the document *Agriculture soil and water conservation and development: Approach to implementing the national agriculture strategy* for use in consultations with the provinces. Staff were also involved in the formulation of the Research Branch strategic documents.

In response to rationalization of research programs, research areas requiring consolidation were identified and a rationale was provided.

Subsequent to the announcement of a new soil conservation initiative, background information was gathered on all conservation-related soil activities in the country. Soil degradation problems were assessed and research needs were identified.

Interbranch and interdepartmental activities

Research Branch and the department were represented on various interjurisdictional forums, including the Interdepartmental Committee on Land (ICL) and the Interdepartmental Committee on Water (ICW). Participation on the ICW Mandate Review Committee assisted in restructuring that committee to make it more effective in coordinating federal water programs. Participation on the ICW Water Quality Subcommittee consisted of coordinating input of Agriculture Canada expertise in the preparation of new water quality guidelines for Canada.

Agricultural interests were also represented on the Nonpoint Source Subcommittee of the Great Lakes Water Quality Board, which is primarily concerned about toxic substances and phosphorus from farmland. One of the sub-committee's tasks was a review of the United States Great Lakes Phosphorus Reduction Plan.

Research Branch participated in the development of the Canadian position on the Brundtland report *Our common future*, published by the World Commission on Environment and Development. The report stresses the need to reconcile environmental protection with economic development.

Faced with the uncertainties surrounding possible climatic changes due to the greenhouse effect issues pertinent to agriculture requiring attention were identified. This is part of a concerted effort by the Departments of Environment, Energy, Mines and Resources, Fisheries and Oceans, and Agriculture Canada (including the Canadian Forestry Service) to mitigate the impact of chemical alterations of the atmosphere.

The issues of impact of long-range transport of air pollutants were evaluated through participation on the interdepartmental committee on this subject.

The directorate participated in the development of the Canadian space program and supported the activities of the Interdepartmental Committee on Space.

Responsibilities were also assumed on interdepartmental committees for coordinating science programs in biotechnology and energy. Memoranda to Cabinet from the Departments of Environment and Energy, Mines and Resources were reviewed and comments provided.

Support to CASCC

In addition to the normal assessment of research needs under CASCC committees and the review of its research recommendations, a secretariat function was provided to the Canada Committee on Land Resource Services.

Extramural activities

Contributions were made to the development of the departmental response to an Order in Council that initiated new environmental impact assessment procedures within the federal government.

Membership on the editorial board of an international journal required reviewing numerous scientific papers, and contacts with universities were enhanced through presentations and round-table discussions with staff and students.

CROP PROTECTION, BIOTECHNOLOGY, AND BIOLOGICAL RESOURCES

Input to policy, planning, and program development

The directorate, in cooperation with the Western Region, developed the biotechnology R&D initiative announced at the Outlook Conference on 15 December 1987. Through this initiative, up to $25 million from the Western Diversification Fund has been committed to help accelerate the economic development and diversification of the agri-food sector through the development and commercial application of new biological technologies.

Assistance was provided to the development of the branch's comprehensive strategic plan through contributions to the working papers entitled *Canadian agricultural research and technology transfer: Planning for the future*, with particular emphasis on Part 1: *Future directions—an overview*.

A workshop on integrated pest management (IPM) for potatoes was held in Fredericton, N.B., 29–30 January 1987. Thirty-seven participants from Agriculture Canada, the provinces, and universities were present. To fill gaps in knowledge in the development of IPM, the need for additional basic studies on the biology of the potato plant and its pests, and the need for more research on biorational and chemical methods of control were stressed. Increased technical support, increased industry involvement, better communication between researchers, extension specialists, and growers, and increased opportunities to travel to research establishments in Canada and to major conferences were identified as high priorities.

Input was provided to a synoptic overview of horticultural research in Ontario based on visits and interviews with scientists and science managers at the major provincial and federal establishments conducting research on horticulture in that province.

Interbranch and interdepartmental activities

The directorate provided leadership for the plant health working group at the joint Food Production and Inspection Branch/Research Branch work planning session held on 31 March 1987, and participated in the activities of the Corporate Committee on Pesticides, the Forest Pest Management Institute Advisory Committee, and the national workshop on the minor use of pesticides program.

A secretariat function was provided to the Ministry of State for Science and Technology (MOSST) for the Task Force on Canadian Culture Collections, and support has been given to the Natural Science and Engineering Research Council's (NSERC) Cell Biology and Genetics Grant Selection Committee by providing a scientific secretary.

Support to CASCC

In addition to the usual review of R&D and non-R&D recommendations, direct input was provided to the Expert Committees on Plant Gene Resources and Pesticide Use in Agriculture.

Extramural activities

Priorities and Strategies Directorate, in cooperation with the Central Region, has made progress in a review of the department's association with CAB International (CABI; formerly known as the Commonwealth Agricultural Bureaux) and the associated CABI Institute of Biological Control (CIBC). This review has been undertaken in light of the need to reassess priorities, to eliminate expenditures that are outside the departmental mandate, and to identify and maintain access to those services that are necessary for program delivery.

Research Branch has cooperated with the Canadian Honey Council (CHC) by continuing to provide the industry with assistance in prioritizing its research needs and in identifying potential research partners outside Agriculture Canada who might assist the industry in meeting research needs that cannot be met by available resources and expertise within the department.

Support for the Gordon Research Conferences (GRC) was provided through assistance with the organization of the GRC on mycotoxins and phycotoxins held at Plymouth, N.H., 29 June–3 July 1987.

FOOD RESEARCH

Input to policy, planning, and program development

The mission of food research in the Research Branch is "to develop and transfer information and technology that will assist the agri-food sector to increase the utilization and market value of commodities through improved processing efficiency, product diversification, and the enhancement of food quality." This statement was developed by directors and section heads in the food research program at a meeting convened by the coordinator for food research. Efforts are being made to develop greater awareness and closer links among the establishments conducting food research.

The department's Program Evaluation Division reported on its evaluation of the branch's food research program in 1987. It found that the food research program provides vital support to Canada's food processing industries, but it is too thinly spread to effectively serve the intended purposes. It recommended that long-term strategic research should be the focus of attention for federal funds, and that applied and developmental research should be conducted in partnership arrangement with industry or other organizations. An implementation plan for the nine major recommendations in the report has been prepared.

Food Research Coordination was involved in a variety of activities throughout the year. These have included assisting in the development of the branch Human Resources Plan, working on the headquarters Information System Committee and responding to branch requests for information on food irradiation.

Secondments

During the year, a branch scientist working in post-harvest physiology was seconded to Ottawa as a special adviser to assist with food research coordination.

Support to CASCC

Both the coordinator for food research and the special adviser provide secretariat functions for the CASCC system. The former acts for the Canada Committee on Food and the latter for the Expert Committee on Refrigeration. Considerable input was provided to the proposal for restructuring of the operating grants program under the Canadian Agricultural Research Council (CARC).

An ad hoc committee on the role of red meat in the diet of Canadians was established by CARC. This committee was requested to develop objective information on the subject.

Interbranch and departmental activities

A departmental nutrition policy, which defines Agriculture Canada's role and responsibilities, has been developed by an intradepartmental committee led by a senior Research Branch scientist, with participation by the food research coordinator.

Other activities undertaken included participation on the Interdepartmental Committee on Food Irradiation, Interdepartmental High Visibility Committees, the Free Trade Exploitation Committee, and the Emergency Preparedness Committee.

Finance, Ottawa, Ontario

PROFESSIONAL STAFF

J.E. Renaud, C.D.	Director
K. Archer, C.M.A.	Chief, Financial Planning and Analysis
A.L. Dignard	Adviser, Eastern Region
G. McKane, B.A., C.M.A.	Adviser, Western Region
J.B. Moran	Adviser, Central Region

INTRODUCTION

The Finance Division is a service organization. It has four major functions: (*1*) to provide all the financial inputs required by the central agencies, (*2*) to direct the budgeting of person-years and dollars, (*3*) to foster the economic, effective, and efficient use of those resources, and (*4*) to provide financial guidance and advice to all levels of management, from the staff of responsibility centres to the level of the Assistant Deputy Minister. These functions are carried out by a core financial planning and analysis group and teams of financial advisers assigned to the three regional directors general. The advisers are members of the regional management committees and the director is a member of the branch management committee.

J.E. Renaud
Director

ACHIEVEMENTS

This year the Finance Division was reunited with the Research Branch after having been part of the Corporate Management Branch for 6 years. The division has been completely reorganized, with emphasis on the delivery of services to line managers. This, along with the return of directors general to Ottawa, has served to reestablish the close communication links with responsibility centres that existed prior to decentralization in 1978.

A good start was made in laying a solid foundation for cooperation and collaboration by having the regional financial advisers visit each responsibility centre early in the fiscal year. Follow-up, on-site consultations occurred later in the year, as well as participation in regional meetings between directors general and directors.

The Finance Division prepared the financial input for Research Branch's portion of departmental reports to Treasury Board, Parliament, and other government departments, i.e., the fall Multi-Year Operational Plan (MYOP), Main Estimates, Supplementary Estimates, Science Addendum, and other submissions and reports.

Guidelines and assistance were provided to managers at all levels for the preparation and validation of annual resource plans and costed work plans.

Budgets totaling 3481 person years and $221.5 million were monitored and controlled throughout the year. This involved the development of alternatives for decisions on resource allocations, reallocations, and reductions; and subsequent adjustments to budgets and allotments, as well as the arrangement of transfers among regions and other branches as needed.

Reports, schedules, briefings, and correspondence for the Minister, Deputy Minister, and the Branch Executive were prepared on financial and related matters. Various cyclical reports such as the variance reports and cash forecasts were prepared.

Industry Relations, Ottawa, Ontario

PROFESSIONAL STAFF

G.M. Weaver, B.Sc., Ph.D.	Acting Director
K.W. Lievers, B.Sc., M.Sc.	Industry relations
J.S. McKenzie, B.S.A., M.Sc., Ph.D.	Industry relations

INTRODUCTION

The Industry Relations Office was organized in August 1987 to develop enabling mechanisms to conduct research in collaboration with other organizations including industry, universities, and provincial agencies and to promote technology transfer. Achievements include completing the first cycle of releasing the department's corn inbred and hybrid lines and establishing with the industry, agreements to cover royalties both in Canada and abroad. Means have also been developed to accept and administer funds from external agencies to conduct collaborative research under partnership agreements.

P.W. Voisey
Acting Executive Director

ACHIEVEMENTS

During 1987, industry relations was studied in depth by four working groups on the following topics: (*1*) mechanisms for receiving industry funds, (*2*) government policy on technology centres, (*3*) principles for collaborative research and contracting-in, and (*4*) advisory boards on research priorities. The final report blended the specific recommendations on each of the four areas, forming one report. In addition, recommendations on implementation were made.

As the first step in implementation, the Industry Relations Office was established. Its role is to facilitate commercialization of new technologies and to increase joint venture R&D activities with the private sector. An Industry Relations Advisory Board has been appointed to establish policy, priorities, and directions for the office and to review progress.

A policy for the release of corn hybrids and inbred lines from all Agriculture Canada research stations was developed with the full cooperation and support of the Canadian Seed Trade Association. The policy establishes a mechanism for the release of inbred lines to research organizations worldwide and hybrids to Canadian seed corn companies exclusively. Companies must sign a contract that establishes Agriculture Canada's proprietary ownership and pay royalties when commercialized.

Management Services, Ottawa, Ontario

PROFESSIONAL STAFF

I.M. Wood	Director
S.C. Cassidy	Planning and systems
M. Craib	Contracts and agreements
D.W. Friel	Head, Assets Management
J. Homewood	Administrative services

INTRODUCTION

The Management Services Division provides administrative services and advice to branch management both at the headquarters level and at the responsibility centre level. These responsibilities are fulfilled through a group of officers and support staff with expertise in the areas of contracts and agreements, general administration, assets management, text revision, and special projects. Some of the senior members of the staff act as liaison officers with the regional directors general and participate as members of the regional management committees. The division also provides support to the branch headquarters staff in such areas as word processing, materiel management, and accounts processing.

I.M. Wood
Director

ACHIEVEMENTS

The Management Services Division was established as a result of a reorganization of the branch management structure. In addition to the reduction in the number of regions and the directors general returning to Ottawa, the regional administration offices ceased to exist and their responsibilities were transferred to headquarters.

The main objective of the division in its 1st year was to promote communication with the responsibility centres and establish lines of responsibility. This was achieved through regional administrative meetings held in Ottawa, Sainte-Foy, and Saskatoon.

Throughout the year, the division performed its role in liaising with other branches of the department on behalf of establishments across the country concerning the various responsibilities associated with administration.

Policy and Client Relations
Ottawa, Ontario

PROFESSIONAL STAFF

D.F. Kirkland	Director
G.W. Andrews, B.Sc.F., M.Sc.	Policy and planning
A.M. Cooper, B.Sc.	Policy Analyst
E.K. Endemann, B.A.	International programs
W.L. Fettes	Branch Liaison – international
J.P. Hayes, B.Sc., M.Sc.	Policy
M.K. John, B.Sc.(Agr.), M.Sc., Ph.D.	Special Adviser, resources
J.A. Perrin, B.Sc.	Operations processes

INTRODUCTION

The Policy and Client Relations Division was formed in 1987 to provide a focal point for directing the policy initiatives undertaken by the branch in support of the department's role in science and technology. The division directs the corporate relations of the branch with its clients inside and outside the federal government and internationally.

Research programs developed along both commodity and discipline lines must conform to broad government economic development as well as to science and technology policies. One of the division's tasks is to analyze and provide guidance on the implementation of policies that will assist the branch to perform its R&D activities.

In 1987, the Policy and Client Relations Division also was charged with the development and implementation of mechanisms to permit use of automated, fully costed work plans. Changes were made to the Branch Head Plan and the Multi-Year Operational Plan in order to reflect the realignment of branch activities and priorities, and to raise the profile of the policy issues addressed in research activities.

Other activities undertaken by the division were as follows: *(1)* preparing the branch's long-term strategic plan and performing a variety of functions associated with this initiative; and *(2)* developing a database on branch international R&D activities and policies.

D.F. Kirkland
Director

POLICY

Response to government issues

Since its inception in mid-1987, the Policy and Client Relations Division has undertaken activities in a variety of policy areas. One focus has been the active liaison with central agencies to provide input for the development and interpretation of federal science and technology-related policies and policy instruments.

Input to federal science and technology policies

The latter part of 1987 was a particularly active period in terms of development of new federal science and technology (S&T) policies and programs. The Ministry of State for Science and Technology (MOSST) drafted a variety of new policy instruments that may have significant implications for research and development (R&D) activities in the public and private sectors. These initiatives, which formed a second phase of the government's S&T strategy called InnovAction, received in-depth analysis and response by the division. The new policies are now awaiting government approval.

Development of research policies and practices

The Research Branch, as one of the federal government's science and technology performers, is affected by government-wide S&T policies and directives. Several current policies are being reviewed to determine their potential impact on branch operations. The government's decision framework for science and technology provides for the assessment of the management of S&T programs within a government-wide context. These directions mesh with the directions that the Research Branch and the department are taking regarding market-oriented strategies, increased client involvement in decision making through consultation and advisory committees, and a focus on long-term S&T to meet the needs of the agri-food sector.

Secondments

On behalf of the branch, the Policy and Client Relations Division is responsible for coordinating an active interchange program with the Food Production and Inspection Branch. This program is designed to provide exposure to the operation of research and regulatory programs. In 1987, Dr. W.A. Charnetski was seconded to the Pesticides Directorate, Mrs. A. Ferguson returned to the Agriculture Inspection Directorate after a 1-year assignment, and Mr. J.P. Hayes joined the Policy and Client Relations Division.

PLANNING

Strategic planning

The branch has made excellent progress toward the development of a comprehensive strategic plan to establish national direction for research and technology transfer. Three parts of a five-part series of working papers were completed and presented to Ministers in July 1987: Part 1. *Future directions—an overview*, Part 2. *Research Branch strategy*, and Part 3. *Provincial perspectives*.

The division participated in discussions held by the Assistant Deputy Minister with various interest groups from the private sector. Consultations took place with industry and with provincial government representatives in each province during October and November, and Part 4 in the series of working papers, *Industry perspectives*, is in preparation. The result has been a better understanding across the country of the direction of future research endeavors.

The need for partnerships has been accepted as well as the understanding that the branch can no longer be all things to all people. It was agreed that the principal role for the branch is long-term research, leadership, and coordination, and that technology transfer is a provincial responsibility which requires an in-depth review on effectiveness of current delivery mechanisms and systems. The consolidation of programs and the better use of existing capabilities were accepted in principle, with specifics to be outlined in a future document on Research Branch proposals for action.

Operational planning

Terminology. To improve the linkage between scientist activities and branch programs, modifications were made to the planning and control terminology in the branch. Branch operations are fully resourced down to the "establishment project," which is the lowest resource accountability level in the departmental reporting system. "Studies," previously known as projects, provide an information base of scientist activities, and are subject to management control.

Operational and work planning. Planning for 1988–1989 is following the format established for the 1987–1988 process. The departmental document *Strategic directions to 1990* sets out the long-term priorities for all branches. The Branch Head Plan, in response to these directions, was completed at the end of December 1987. This plan also identifies realigned branch activities and priorities, incorporates policy issues affecting research activities, and provides guidance for the preparation of regional and establishment work plans. An automated system has been developed so that the plans will be available on AgriNet for searching and copying.

The following operational planning framework is being used by the branch for planning in 1988–1989:

1.0 Scientific research and development
    1.1 Management and administration
    1.2 Resource research
    1.3 Animal research
    1.4 Crops research
    1.5 Food research

These simplified titles allow for research emphasis on marketability in planning for 1988–1989 and beyond.

Full costing of work plans. A system has been implemented to determine the full cost of commodity research programs, as background information for program rationalization and resource realignments in response to the agricultural research strategy consultations with industry and the provinces. For display purposes, overhead and indirect costs are allocated to commodity projects in order to obtain a truer picture of the "cost of doing business." Budgeting and control continue to be structured according to the operational planning framework.

REPORTING AND CONTROL

Study selection and assessment

In response to Auditor General concerns, a system was developed for selecting, monitoring, and assessing research studies. The resulting *Guidelines and instructions for study selection and assessment* document provides standard guidance to assist managers in selecting research studies that will respond to the needs of clients as well as relate directly to establishment, branch, and department priorities and objectives. The guidelines will also provide a much-needed standard across the branch for the assessment of studies.

Reporting to Treasury Board and Parliament

The Policy and Client Relations Division prepared the Research Branch sections in three departmental reports to Treasury Board and Parliament: the Multi-Year Operational Plan, the Main Estimates Part III, and the Annual Report of the Minister. These reports provide an opportunity for the branch to clearly outline its concerns, opportunities, and resource needs for the upcoming fiscal year, and to describe its achievements of the previous year.

Quarterly reporting

The quarterly operational variance reports continued to be the main mechanisms for reporting major achievements, major variances against plans, and factors that may impact on future progress across the branch. For the 3rd and 4th quarters the Branch Head Report has proved to be a useful document, especially for recording major management and operational achievements, as well as the resulting client benefits and program effects.

INTERNATIONAL RESEARCH AND DEVELOPMENT

Research Branch scientists maintain a vigorous program of international science and technology exchanges with agricultural researchers around the world. The branch also supports departmental objectives in the development, maintenance, and expansion of export markets by providing technical expertise to other branches and agencies. The branch contributes to technological advancement in less developed countries through participation in official development assistance programs as both managers and researchers, and by training foreign scientists in research stations. All these activities were coordinated within the Priorities and Strategies Directorate. Bilateral and multilateral projects and relations were coordinated with some 55 countries and international agencies in order to enhance our domestic research capability and to ensure that Canadian government policies on agricultural science and technology were supported and encouraged internationally.

The branch was responsible for the management of 10 Official Development Assistance (ODA) projects in six countries, funded by the Canadian International Development Agency (CIDA), and seven ODA projects in six countries funded by the International Development Research Centre (IDRC). Branch scientists also provided scientific expertise for a wide range of other international activities for CIDA and IDRC.

In 1987, approximately 100 foreign scientists visited branch establishments for training in techniques directly applicable to their country's agricultural development.

Branch specialists continued throughout the year to investigate and resolve technical issues related to the international marketing of Canadian agricultural products. Scientific and technical assistance was provided by the branch in support of Canadian promotional activities, such as technical seminars and trade expositions aimed at expanding foreign markets for Canadian agricultural products.

Research Program Service
Ottawa, Ontario

PROFESSIONAL STAFF

Administration

Y. Bélanger, B.Sc.	Director
H. Pitt,[1] B.A.	Administration and awards
W.L. Fettes[2]	Branch liaison

Art and Design

C.N. Halchuk	Head of Section

Audiovisual

W.G. Wilson	Head of Section

Scientific Editing

S.M. Rudnitski, B.Sc.	Acting Head of Section
S.V. Balchin	Editing
N. Rousseau, B.A., M.A.	Editing
D.R. Sabourin, B.A.	Editing
F. Smith, B.A.	Editing

Scientific Information Retrieval

J. Taky,[3] B.A., B.Sc., M.P.A.	Head of Section
H.S. Krehm, B.A., M.A., Ph.D.	Chief, Pest management unit
C.D. Laing, B.Sc., M.Sc.	Chief, Inventory and systems
P. Beauchamp, B.Sc., M.Sc.	Herbicides
J.R. Kennett, B.Sc.	Inventory and systems
E.K. McMillan, B.Sc.	Inventory and systems
R. McNeil, B.Sc.	Inventory and systems

Departures

J.A. Perrin, B.Sc. On special assignment with Branch Headquarters from May 1987	Head of Section
D.W. Friel Appointed to Management Services Division, 1 October 1987	Administration and awards
A. Severn Appointed to Management Services Division, 13 October 1987	Administration and awards, acting
R. Makowski, B.Sc., M.Sc. Educational leave, September 1983	Scientific information

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[1] Appointed October 1987.

[2] Seconded 1 June 1987 to Policy and Client Relations Division.

[3] On Career Assignment Program (CAP) from 1 June 1987.

INTRODUCTION

Research Program Service (RPS) supports research and development in the branch as well as technology transfer and scientific knowledge diffusion by maintaining computerized scientific and technical information systems, providing publication services, providing audiovisual and art services, and administering branch awards and international scientific exchange programs.

During 1987, RPS staff started several integrated computer systems aimed at improving turnaround time and reducing the cost of art production and desktop publishing as well as improving existing equipment in the area of slide production. The Art and Design, Audiovisual, and Scientific Editing sections combined their efforts to maintain a suitable quality of production for the dozen or so different types of publications and support material they produce. These materials are designed to ensure an effective transfer of technology and knowledge to the scientific community and the agri-food sector. This year staff began to use new technology to reduce turnaround time and cut production costs, with considerable success. A new database management system (DBMS) was acquired to enable the expansion of existing databases on pest management and the establishment of a new database on current research activities within the branch. The new DBMS is located on Vax B and is therefore accessible to all research establishments.

Further information can be obtained from the Director, Research Program Service, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6; Tel. (613) 995-7084.

Yves Bélanger
Director

ADMINISTRATION

Research Program Service continued to administer the operating grants and visiting fellowships during 1987. Operating grants were awarded to individual researchers at Canadian universities as contributions toward the costs of proposed research projects that will benefit the agricultural industry. Three representatives from Agriculture Canada, seven representatives from faculties of agriculture and veterinary science, and one representative from the Canadian Agricultural Research Council made up the selection committee. In 1987 the committee received 289 applications for operating grants.

The visiting fellowship program gives promising young scientists from all over the world an opportunity to work with distinguished researchers in their respective fields before embarking on careers in scientific research. The Natural Sciences and Engineering Research Council administers the program on behalf of Canadian government departments and agencies. Research Program Service acts as liaison between the council and Agriculture Canada. In 1987 RPS received 280 applications for fellowships in this department.

The Text Processing Unit has tested several desktop publishing systems over the past year. This new technology, when adopted, will realize substantial savings in both time and money.

ART AND DESIGN

The Art and Design Section continued to provide a wide variety of art and related services to the branch and other departmental agencies.

Art production and printing of 83 publication projects, 54 seminar display projects, 565 jobs requiring research graphics illustration work, and more than 2000 photomechanical transfer (PMT) prints for art purposes and reproduction were completed during the past year.

The section was also involved in the assessment of several computer equipment packages that will play an important role in future art services.

AUDIOVISUAL

The Audiovisual Section continued to provide a wide variety of photographic, computer graphic, and audiovisual services to the branch. Production levels throughout the section were much the same as the previous year; however, field photography decreased

27% and micro/macro photography increased 23%, to a total of 7359 photographs taken.

Dynophot, a highly sophisticated macro photographic lighting system, was acquired in 1987. It gives a much greater depth of sharp focus when photographing insects and other macroscopic subjects. With this lighting system the photographer can achieve depths of field two or three times that of a standard lighting system.

High-resolution, full-color, computer graphic slides continued to be the fastest growing product in the section.

SCIENTIFIC EDITING SECTION

For the first time this year Research Program Service achieved success with desktop publishing. Using the Communications Branch system, the editors worked with word-processing personnel to revise, format, typeset, and lay out automatically in pages the annual *Research Branch Report*, without resorting to the use of outside typesetting professionals. The savings in typesetting and layout costs on this project alone amounted to $12 000. Since then, editors have developed procedures for processing all free departmental publications on this equipment. Besides the savings in typesetting costs, the new technology has reduced the production time for short, typeset documents by 3 months.

Research Program Service issued 19 departmental publications during the year for national or international distribution, of which 14 were priced books of high quality. The Scientific Editing Section began negotiations with Supply and Services Canada this year to have the government publisher provide better publicity and promotion for the priced publications written by branch scientists, and the following books published for sale to the agri-food sector were among the first to enjoy the benefits of wider promotion: *Solar Greenhouses for Commercial Growers*, *Serres solaires commerciales*, *Energy-conserving Urban Greenhouses for Canada*, and *Les économies d'énergie dans les serres urbaines au Canada*. Within the year the English and French publications on energy-conserving urban greenhouses were into a second printing.

Several important reference books of prestige quality were made available for sale in bookstores across Canada this year, including the following:

- *The Metallic Wood-boring Beetles of Canada and Alaska*, Part 15 of the *Insects and Arachnids of Canada* series
- the second edition of *The Canadian System of Soil Classification* and *Le système canadien de classification des sols*
- a revision of the popular *Budd's Flora of the Canadian Prairie Provinces*
- *Manual of Nearctic Diptera, Volume 2*, the second in a internationally recognized series of three references on the two-winged flies of North America
- *Common Weeds of Canada* and *Weeds of Canada*, a companion duo aimed at the amateur naturalist and the more serious student of botany, co-published by NC Press Limited in Toronto; and the French counterpart *Les plantes nuisibles communes du Canada*, co-published by Éditions Marcel Broquet in Quebec
- the long-awaited *Compendium of Plant Disease and Decay Fungi in Canada*, which replaces Conners' *An Annotated Index of Plant Diseases in Canada* published in 1967
- a reprint of the useful *Prairie Grasses Identified by Vegetative Characters.*

The following were among the shorter, free departmental publications released in 1987:

- *Alsike Clover*
- *Le trèfle d'alsike*
- *Aphids Infesting Potatoes in Canada: A Field Guide*
- *Growing and Managing Alfalfa in Canada.*

A total of 60 branch publications were produced during the year. Of the 11 reports issued by Agriculture Canada's expert committees and 38 technical bulletins, one, *Pesticide Research Report 1986*, was offered for sale for the first time through Supply and Services Canada. All other branch publications were printed in small quantities for free distribution by the authoring establishment to local or specialized audiences.

SCIENTIFIC INFORMATION RETRIEVAL

The Inventory of Canadian Agri-food Research (ICAR) was updated in the course of the year. Additional information was collected on behalf of the Dairy Farmers of Canada (DFC) to assist in the compilation of the DFC annual report. The Scientific Information Retrieval Section (SIRS) continued to provide access to this computerized database across Canada to the whole research community and to Research Branch personnel. The 1987 version of ICAR provides information on over 4500 agri-food research projects. The distribution of research effort by commodity and discipline was tabulated in the ICAR summary tables, which were widely distributed. In addition, an Inventory of Biotechnology was generated from ICAR on behalf of the Canadian Agricultural Research Council (CARC) and was well received across Canada. Visiting delegations were welcomed from Malaysia, and information about the section's current databases was made available to them.

Following a recommendation of the Research Branch Decision Information Systems Planning (DISP) report, the study database is being developed for all branch establishments and is expected to become operational next year. It is primarily a scientific reporting and retrieval system that contains information on studies done at research establishments. The study database is intended to provide information needed at both the establishment and headquarters level.

All components of the Pesticide Management Research Information System (PRIS) were updated and maintained. PRIS continues to provide to subscribers across Canada on-line access to current pest management research information. Studies are under way on the addition of several new components to PRIS, stressing the newer trends of biological control, biotechnology, integrated pest management, and non-pesticidal research to control plant and animal pests in agri-food production systems.

The section continued to administer the minor use of pesticides program and to coordinate the activities of the various agencies concerned. In 1987, 26 submissions to the program were received and 25 new uses accepted for registration. This program has improved Canada's production capability on a wide range of crops and brought about substantial gains for producers. Furthermore, it is an important production tool in the area of new crop development programs. Reports on the minor use program are disseminated through the quarterly newsletter *Pesticide Information* to members of the agricultural industry, growers, scientists, and provincial extension specialists.

Research Program Service, in collaboration with the Canadian Phytopathological Society, plans to publish a report of disease highlights of the previous year in each spring issue of *The Canadian Plant Disease Survey*. Each report will cover the main horticultural and cereal crops, and it is hoped that this effort will greatly enhance early reporting of the onset and spread of the more important disease pathogens affecting Canadian crops in time to take remedial action.

In addition to their regular activities, section staff supported the Expert Committee on Pesticide Use in Agriculture, the Expert Committee on Weeds, the Western Expert Committee on Grain Diseases, the Eastern Expert Committee on Grains and Oilseeds, the Canada Committee on Crop Production, the Canada Committee on Food, the Canadian Horticultural Council, and the Canadian Standards Association.

Eastern Region
Région de l'Est

Y.A. Martel

W.B. Collins

D. Demars

A. Dignard

Director General *Directeur général*	Y.A. Martel, B.A., B.Sc.(Agr.), Ph.D.
Regional Program Director *Directeur régional des programmes*	W.B. Collins, B.Sc.(Agr.), M.Sc., Ph.D.
Regional Executive Director *Directeur exécutif régional*	D. Demars, B.Sc., M.Sc., Ph.D.
Financial Officer *Agent de finances*	A. Dignard

PREFACE

The Eastern Region, with headquarters in Ottawa, consists of 10 research stations, two research centres, eight experimental farms, and several substations. These research establishments serve the agricultural communities in six provinces, namely Newfoundland, Prince Edward Island, Nova Scotia, New Brunswick, Quebec, and Ontario. In 1987, the region managed a budget of about $73 million and employed some 360 professionals to carry out its programs.

Effective 1 April 1987 a major reorganization took place in the Research Branch, which brought about important changes in the organization. The former Atlantic, Quebec, and Ontario regions were merged into one under the leadership of Dr. Y. Martel, who had previously been director general of the Atlantic Region. Mr. J.-J. Jasmin, former director general of the Quebec Region, retired in 1987. Dr. J.J. Cartier of the Ontario Region had been named director general of the Central Experimental Farm Directorate in 1986. Research programs in 1987 encompassed the following in the three areas.

Atlantic Provinces: soil management, which includes the development of practical technology to cope with erosion, drainage, and the physical constraints related to impermeable subsoils; livestock and livestock feeds research, to develop improved feeding and management systems with particular emphasis on the utilization of locally produced feedstuffs for beef and dairy cattle, swine, and poultry operations; cereal research, concerned with developing and identifying superior cereal cultivars meeting regional requirements for yield, disease, cold tolerance, and climatic adaptability; forage crop research, to develop superior forage management techniques and the breeding and testing of new cultivars; and horticultural crops research on potatoes, other vegetables, tree fruits, berries, and ornamentals.

Quebec: soil conservation and improvement, to establish optimum fertilization rates for various crops and continued studies to obtain strains of *Rhizobium* more resistant to low temperatures and endomycorrhizae specific to various crops; livestock research, designed to improve feeding and management systems for beef cattle, dairy cattle, and sheep; cereals research, to develop and identify superior cultivars that meet the needs of Eastern Canada; forage research, developing new varieties and improved crop management techniques; horticultural research, focusing on various types of vegetables, orchard fruits, aromatic plants, and ornamentals; food processing research, using biotechnology and food engineering to develop new technology for processing dairy, meat, and plant products and extending storage life. The new Saint-Hyacinthe Food Research Centre was inaugurated in June 1987.

Ontario: multidisciplinary field crops research and development, aimed toward developing new varieties and generating appropriate crop husbandry practices for corn, soybeans, winter wheat, field beans, and horticultural crops; sandy soil research on tobacco and tobacco alternate crops; pest management for orchard and vegetable crops; animal and plant research, developing improved beef production systems for northern Ontario and western Quebec; pest management and environmental toxicology and quality research, involved with reducing the dependence of the agri-food industry on pesticides; research on food processes, improving the quality, safety, and nutritive value of food.

Staff changes in 1987 included the following. Dr. Ken Proudfoot has been acting as director at St. John's West; Dr. Doug McBeath was appointed director at Fredericton; and Dr. Paul Burgess was appointed superintendent at Nappan, replacing Frank Calder who retired.

Further information about our programs may be obtained by contacting directly the establishment concerned or by directing inquiries to Eastern Region Headquarters, Research Branch, Agriculture Canada, 930 Carling Avenue, Ottawa, Ont. K1A 0C5; Tel. (613)995-7084.

Y. Martel
Director General

PRÉFACE

La Région de l'Est, située à Ottawa, comprend dix stations de recherches, deux centres de recherches, huit fermes expérimentales et quelques stations satellites. Les établissements de recherches dispensent leurs services aux collectivités agricoles dans six provinces, soit Terre-Neuve, l'Île-du-Prince-Édouard, la Nouvelle-Écosse, le Nouveau-Brunswick, le Québec et l'Ontario. En 1987, la Région a géré un budget de 73 millions de dollars et a employé quelque 360 professionnels pour mener à bien ses programmes.

Le 1er avril 1987, on a effectué une importante réorganisation de la Direction générale de la recherche. Les régions de l'Atlantique, du Québec et de l'Ontario ont été fusionnées sous la direction du Dr Y. Martel qui était auparavant directeur général de la Région de l'Atlantique. Monsieur J.-J. Jasmin, alors directeur général de la Région du Québec, a pris sa retraite en 1987. Dr J.J. Cartier, directeur de la Région de l'Ontario, a été nommé, en 1986, directeur général de la Direction de la Ferme expérimentale centrale. Les programmes de recherches en 1987 comprenaient ces trois régions.

L'Atlantique : l'aménagement des sols comprend le développement de technologies pratiques destinées à résoudre les problèmes d'érosion, de drainage ainsi que des contraintes physiques liées aux sous-sols imperméables; les recherches sur les bestiaux et leur alimentation mettent au point des régimes d'alimentation et des pratiques d'élevage susceptibles d'accroître l'utilisation du fourrage produit localement pour les bovins de boucherie et les bovins laitiers, les porcs et la volaille; les recherches sur les céréales sont axées sur la création et l'identification de cultivars supérieurs susceptibles de répondre aux besoins régionaux; les recherches sur les fourrages améliorent les techniques culturales, sélectionnent et essaient de nouveaux cultivars; les recherches horticoles incluent la pomme de terre, d'autres légumes, les fruits de verger, les petits fruits et les plantes ornementales.

Le Québec : le programme de conservation et d'amélioration des sols vise à établir des taux optimums de fertilisation pour différentes cultures ainsi que pour obtenir des souches de *Rhizobium* plus résistantes aux basses températures et d'endomycorhizes spécifiques à plusieurs cultures; les recherches sur le bétail ont pour objet d'améliorer les systèmes d'alimentation et de conduite des bovins de boucherie, les bovins laitiers et les ovins; le programme de recherches sur les céréales a pour objet de développer et d'identifier les cultivars supérieurs capables de satisfaire les besoins de l'est du Canada; le programme de recherches sur les plantes fourragères vise à mettre au point des techniques supérieures de gestion des cultures; les recherches en cultures horticoles portent sur diverses espèces de légumes, les fruits de vergers, les plantes aromatiques et les plantes ornementales; la recherche sur la commercialisation des aliments fait appel à la biotechnologie et au génie alimentaire pour développer de nouvelles technologies et procédés de transformation de produits laitiers, carnés et végétaux. Le nouveau Centre de recherches alimentaires de Saint-Hyacinthe a été inauguré en juin 1987.

L'Ontario : les activités pluridisciplinaires de recherches et de développement sont axées sur la création de nouveaux cultivars, la mise au point de pratiques culturales appropriées pour le maïs, le soja, le blé d'hiver et le haricot ainsi que sur des cultures horticoles; la recherche sur sol sablonneux de tabac et d'une culture de remplacement; les études sur la lutte intégrée contre les ravageurs des cultures de vergers et des productions maraîchères tentent de réduire l'épandage de pesticides chimiques; le programme de recherches sur les animaux et sur les plantes vise la mise au point de systèmes améliorés d'élevage de bovins de boucherie pour le nord de l'Ontario et l'ouest du Québec; les recherches sur la lutte intégrée contre les ravageurs, sur la toxicologie et la qualité de l'environnement visent à diminuer les pesticides; les recherches sur les aliments s'efforcent d'améliorer la qualité, l'innocuité et la valeur nutritive des aliments.

En 1987, il y a eu certains changements dans le personnel : Dr Ken Proudfoot a été nommé par interim directeur à St. John's West; Dr Doug McBeath a été nommé directeur à Frédéricton et Dr Paul Burgess a remplacé comme surintendant à Nappan M. Frank Calder qui a pris sa retraite.

Pour obtenir de plus amples renseignements sur nos programmes, il faut écrire aux établissements concernés ou adresser les demandes à l'Administration centrale de la Région de l'Est, Direction générale de la recherche, Agriculture Canada, 930 avenue Carling, Ottawa (Ont.) K1A 0C5; Tél. (613) 995-7084.

Y. Martel
Directeur général

Research Station
St. John's West, Newfoundland

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B.G. Penney, B.Sc., M.Sc.	Vegetable crops

Plant Breeding and Pathology

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M.C. Hampson, B.Sc., M.Sc., Ph.D.	Plant diseases

Agricultural Engineering

G.A. Bishop, B.Eng., M.A.Sc.	Agricultural machinery

Entomology (Vacant)

Agronomy (Vacant)

INTRODUCTION

The research station located at St. John's West is responsible for agricultural research in Newfoundland and Labrador. Plant breeding includes the development of potato cultivars resistant to cyst, or golden, nematode and potato wart disease, and rutabagas resistant to clubroot disease. The plant pathology program concentrates on studies of the potato wart disease organism. The entomology program has investigated insect pests of horticultural and forage crops, and maintains an extensive collection of Newfoundland insects. Research is conducted on the development and utilization of peat soils for horticultural and forage production at the Peat Research Substation, Colinet, and on the management of lowbush blueberry stands at the Avondale Substation.

This report provides brief summaries of some of the results obtained in 1987. Further information, reprints of listed publications, and copies of previous reports can be obtained from the Research Station, Research Branch, Agriculture Canada, P.O. Box 7098, St. John's, Nfld. A1E 3Y3; Tel.(709)772-4619.

K.G. Proudfoot
Acting Director

HORTICULTURE

Peat soil

In 1987, replicated trials were conducted at the Peat Research Substation, Colinet, to determine (*1*) the fertilizer requirements for celery (cultivar Stokes Improved Utah 52-70), and (*2*) the fertilizer and spacing requirements for mid-season cabbage (cultivar Stonehead). Treatments evaluated for celery were as follows: factorial combinations of N at 250, 350, 450, and 550 kg/ha; P at 43.6, 87.3, 130.9, and 174.6 kg/ha; and K at 207.5, 290.5, 373.6, and 456.6 kg/ha. Treatments evaluated for cabbage were as follows: factorial combinations of N at 350, 500, 600, and 700 kg/ha; K at 290.5, 415.1, 498.1, and 581.1 kg/ha; and row spacings of 36, 46, and 56 cm. Vegetable transplants were used in both experiments and weeds were controlled with black plastic mulch.

Celery. No response was obtained with phosphorus, but N produced significantly higher yields at 250 kg/ha than at the higher rates evaluated. Yields were also increased as levels of K were raised from 207.5 to 456.6 kg/ha.

Cabbage. Neither plant density nor rate of N affected marketable yields, but there was a highly significant interaction between rate of N and K. At the lowest N rate of 350 kg/ha, marketable yield increased steadily with increases in the K rate from 290.5 to 581.1 kg/ha. However, as the N rate was increased further, the increase in yield became less pronounced with increases in the K rate. At the highest N rate of 700 kg/ha, yields decreased with increases in the K rate.

Increasing the N rate from 350 to 700 kg/ha and decreasing plant density from 92 593 (36-cm spacing) to 59 524 (56-cm spacing) plants per hectare significantly increased marketable head weight.

Cabbage root maggot control. Rutabaga transplants treated with a 20 mL drench per plant of either Chlorfenvinphos (1.0 g Birlane 25 WP in 1 L water) or fensulfothion (2.0 mL Dasanit 720 EC in 1 L water) 1 week prior to field planting were effectively protected from damage by the cabbage root maggot. Yields of marketable roots from four replicate 10-m single-row treated plots averaged 49.9 kg at St. John's compared to 12.5 kg from untreated plots, and 17.5 kg at Wooddale compared to 0.0 kg from untreated plots. In plots that were given a second drench of insecticide 6 weeks after field planting, the infestation index was reduced but there was no increase in yield of marketable roots. Initially, treatments with Dasanit caused some leaf distortion and a paling of the leaves, but these symptoms had disappeared by midsummer.

PLANT BREEDING AND PATHOLOGY

Potato breeding

In the continuing program to develop cultivars resistant to both cyst nematode and wart disease, a blue-skinned late-maturing selection N1051-1 has been identified as having considerable commercial potential. Yields have been similar to those of Blue Mac but the dry matter content has been higher. Seed of this selection is being increased and additional trials on commercial farms are being undertaken in 1988. Selection N1051-1 resulted from a cross of the wart resistant cultivar Blue Mac with a wart and nematode resistant selection N491-2. Cultivars and selections with resistance to wart, nematode, scab, viruses, and greening on exposure to light were used in the breeding program. In single hill plots, attractive tubers were produced from crosses with the cultivar Redsen, particularly between Mirton Pearl and Redsen. At the wart evaluation trial site at Avondale, less wart than usual was observed due to below average rainfall during the summer months. However, in the NE107 trials the following cultivars and selections were found to be fully susceptible: NY71; NY76; NY79; CS7635-4; A465-2; A7411-2; A72685-2; Coastal Russet. Trace infections were found on W572 and NY72, whereas NY81 was free from infection, although in a previous test both NY72 and NY81 had been susceptible. Hampton was again found to be resistant to both cyst nematode and wart disease, but it was susceptible to scab disease.

Rutabaga breeding

Seed stocks of the cultivar Kingston were produced at the research station, and seed plots were grown for multiplication of two lines resistant to cabbage root maggot – one with a green-topped root and the other with a purple-topped root. An intercrossing block of roots that had been selected from several crosses aimed at combining resistance to both insect pests and diseases with desirable horticultural characteristics was also established. The roots of plants from cabbage root maggot resistant lines were much less severely damaged than roots from unselected lines, and this material appears to have good commercial potential. Plots of earlier generation lines from which the cultivar Kingston had been developed were grown. Plants were reevaluated for disease resistance and for color and shape of roots. In comparison to these lines, Kingston was equal in clubroot resistance but was much superior in appearance.

Plant pathology

Soil amendments. In the greenhouse, it was found that chitosan reduced the incidence of potato wart disease. Its influence in suppressing the disease was erratic, however, and not as predictable as that of crab meal. Tests to reexamine the influence of the various chemicals previously tested for wart suppression are continuing but under increasingly rigorous conditions. In the field, potato wart disease was suppressed successfully when crab meal was applied either in the drill or as a broadcast material.

Germination. Germination conditions in vitro are being evaluated. Of the many buffer systems assayed, only citrate–phosphate allows germination. Solution molarity is also influential, 10 m*M* being optimum; pH values for germination are at ca. 5. The aim of this work is to develop an optimum culture solution using cations, antibiotics, and other additives.

Bioassay. The nodal cutting assay system reported previously has demonstrated successfully the presence of one resting spore of *Synchytrium endobioticum* in 2 g infested soil. This system is being developed to provide a tool for testing suspect soils within the framework of quarantine legislation, and modified for the axenic production of *S. endobioticum* for basic studies on the biology of the fungus.

AGRICULTURAL ENGINEERING

During 1987, a modified carrot harvester was tested on organic soil. Improvements in control systems and machine flotation effectively improved the ability of the machine to pull and top carrots. A plow point installed to loosen the carrots in the soil was found to be too large and lifted an excessive amount of soil with the carrots. The gathering points of the machine tended to plug with soil when carrots that had been planted on flat ground were harvested. Further testing will be performed in 1988.

Field conditions have been improved by a combination of draining and leveling. A newly purchased tractor modified for use on peat soils will be used for further evaluation of a chain-type trencher used for drainage work. Cleaning teeth have been installed on the trencher to improve its performance in wet peat and a pipe chute for simultaneous laying of plastic drainage tubing has been designed for testing in 1988.

AGRONOMY

Forages. As part of the Atlantic Canada cooperative forage evaluation program, five cultivar trials were maintained at St. John's and Colinet during 1987. Four new trials were seeded, but because of dry weather seed establishment has been erratic and reseeding will be necessary. Herbage yields in all trials were lower than normal, but the meadow fescue cultivar Trailer and the meadow fescue perennial rye grass hybrid Prior were less affected by the weather conditions than cultivars of other species. As a result of these cooperative trials, the red clover cultivars Marino and Jubilatka have been recommended for registration for use in Canada.

Research Station, Charlottetown Prince Edward Island

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Departure

D.C. Read, B.Sc.(Agr.), M.Sc., Ph.D.	Pesticide degradation, vegetable insects

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[1] Seconded from Libraries Division, Corporate Management Branch.
[2] Economic Regional Development Agreement (ERDA) project to December 1987.
[3] Joined staff April 1987.

INTRODUCTION

The research station at Charlottetown has Atlantic Region responsibility for research on the production and utilization of livestock feed crops (forages, cereals, protein), tobacco, and certain vegetable crops (cole, peas) grown for processing. Emphasis on potato research is in the areas of nutrition and management for processing and table potatoes, and for small whole-seed potato production. Research is also conducted on disease evaluation and weed and pest control.

In November, Dr. Pushpal Narasimhalu completed a 1-year transfer of work to the Swedish University of Agricultural Sciences, Uppsala, Sweden, where he worked on using plant growth regulators to modify forage crop quality (6 months) and to the Université Catholique de Louvain, Belgium, where he studied the effect of newer forms of enzyme additives on silage fermentation and quality.

Rollin Andrew, research economist, completed an M.Sc. program in production economics at the University of Alberta, Edmonton. Dr. Jeff Stewart completed his Ph.D. program in integrated pest management (IPM) at the University of Guelph and initiated a research program in potato and cole crop IPM.

Dr. Dean C. Read retired in June following 36 years of service, and his research program on pesticide degradation was terminated.

In 1987 the tobacco research program was reduced by 50% and these resources were diverted to the forage and potato programs.

This report includes brief summaries of some of the research completed in 1986. More detailed information may be obtained by referring to the station's research summary, which is published annually, or by contacting the Research Station, Research Branch, Agriculture Canada, P.O. Box 1210, Charlottetown, P.E.I. C1A 7M8; Tel. (902) 566-6800.

L.B. MacLeod
Director

CEREAL CROPS

Breeding and testing

Spring barley. A new barley (*Hordeum vulgare* L.) variety, Albany, was released by the Charlottetown Research Station in 1987. Albany is a two-row, spring feed barley. It was derived from a Summit × I.B.6-3 (rh) cross. I.B.6-3 (rh) is a scald-resistant line developed by the Lethbridge Research Station. Albany has high yield, good kernel weight, and resistance to powdery mildew and smuts. It is susceptible to net blotch, scald, and barley jointworm. Albany is well adapted to eastern Canada.

New early-maturing corn hybrids recommended for Atlantic Region. Each year new commercial early-maturing corn hybrids are evaluated for silage and/or grain production at seven locations in Nova Scotia, New Brunswick, and Prince Edward Island to support the licensing and/or recommendation of hybrids. Four new grain hybrids and five new silage hybrids were added to the regional recommended lists for corn. Based on these trials, the Atlantic Advisory Committee on Corn submitted licensing support data for seven new corn hybrids. Four of these were developed by the Ottawa Research Station and two were the earliest grain corn hybrids in the trials, giving grain yields over 5.3 and 5.4 t/ha (based on 15.5% moisture grain) with at-harvest grain moisture contents of 23.6 and 25.2% averaged over all trial locations.

Corn emergence rates differ under Maritime conditions. Emergence data from the Atlantic corn hybrid evaluation program field trials over 4 years indicated some hybrids exhibit poor emergence characteristics under Maritime conditions. Emergence rates as low as 65% of seeds planted occurred consistently with some hybrids. Six hybrids currently recommended for the region were found to give less than 90% emergence in 75% of the trials over the 4-year period. Emergence rate has been added to the criteria evaluated in the recommending of new corn hybrids for the region.

Diseases and pests

Fusarium infection of wheat and barley heads. Small blocks of wheat (cultivar Vernon), and of barley (cultivar Birka) were sampled throughout the 1986 and 1987 seasons and the heads tested for infection by *Fusarium* species. The four species of *Fusarium* that predominated were *F. graminearum*, *F. avenaceum*, *F. sporotrichiodes*, and *F. poae*. In 1985, cool wet weather favored infection by *F. graminearum*, whereas in 1986 *F. poae* was favored, possibly as a result of the warm and dry weather conditions in that year. Results of sequential sampling indicated that there was continual *Fusarium* infection of the heads taking place from head emergence to shortly prior to harvest. There were, however, noticeable shifts in the relative predominance of the various *Fusarium* spp. recovered.

Net blotch and yield response to propiconazole application in barley. Single applications of the foliar fungicide propiconazole (Tilt) to barley resulted in a 7-year mean yield increase of 660 kg/ha (22.9%) over untreated controls. Net blotch control in excess of 80% was observed in some years, with a significant negative correlation between net blotch and yield in 6 of 7 years. A separate 2-year test on number of applications indicated a yield benefit of 715 kg/ha (23%) from single applications of propiconazole and 1075 kg/ha (34.6%) from double applications.

Chlorsulfuron use in barley and residual effect on potato and rutabaga grown in rotation. Experiments were conducted over 4 years (1980–1983) to determine the efficacy of chlorsulfuron for use on spring barley (*Hordeum vulgare* L.), and the effects of herbicide residue on crops grown in rotation. Barley cultivar Volla tolerated chlorsulfuron with active ingredient (a.i.) at rates up to 72 g/ha with no significant yield reductions being noted. Lamb's-quarters and corn spurry were controlled with a.i. at applied rates of 9–18 g/ha, but a.i. at a rate of 36 g/ha was needed to control wild buckwheat. Rotation crops of rutabaga and potato, grown the season after chlorsulfuron use, showed no adverse effects on marketable or total yield. It was estimated from corn root bioassay studies that chlorsulfuron with a.i. at applied rates of up to 10 g/ha would not carry over into the next season under Prince Edward Island conditions.

Metsulfuron use in barley and residual effect on succeeding crops. Experiments conducted over 4 years (1982–1985) determined the efficacy of metsulfuron for use in spring barley *Hordeum vulgare* L. 'Volla' and effects of residues on crops grown the next season. Barley tolerated metsulfuron with a.i. at rates up to 72 g/ha with no significant effects on yield but 1000-kernel weight was reduced in two of the barley crops grown. Control of lamb's-quarters and low cudweed was acceptable and that of corn spurry and shepherd's-purse better than with the standard 4-chloro-2-methylphenoxyacetic acid (MCPA) amine treatment. There was no significant effect on marketable and total yield of rutabaga (*Brassica napobrassica* Mill.) or potato (*Solanum tuberosum* L.) and none on yield of silage corn (*Zea mays* L.) when each was grown the season after metsulfuron use. Reductions in corn root growth were noted in bioassay tests as late as 120 days after metribuzin application, but the lack of effects on yields of succeeding crops would indicate that the remaining residues were broken down or diluted by plowing and working the soil.

SOIL MANAGEMENT AND CONSERVATION

Management

Soil erosion losses under freeze/thaw and winter ground cover. A laboratory rainfall simulator was used to test three Prince Edward Island agricultural soils (varying in soil texture) for runoff, splash volume, and sediment loss under varying conditions of freeze/thaw, ground cover, and erosivity. Wooden soil boxes and ancillary collection frames (termed cassettes) were designed to fit four at a time under the rainfall simulator. With bare soil, freeze/thaw conditions significantly increased sediment loss by about 90%. In addition, sediment in runoff varied significantly with soil type and, for a loam soil, was 15 and 31%, respectively, of the amounts for a fine sandy loam and a sandy loam. Where the soil was seeded to a winter rye cover, sediment loss was reduced by 70–80% with no significant effect of soil type or freeze/thaw. However, where the erosive force was increased by adding overland flow to simulated rainfall, there was a significant increase in sediment loss, even with ground cover.

Sediment splash was sampled for all tests, and only ground cover indicated a significant effect.

Biological properties and the relationship between microbial biomass nitrogen (N) and mineralizable N. The mineral N flush, a measure of microbial biomass N, and the N mineralization potential (N_0) were determined in eight representative agricultural soils (Humo-Ferric Podzols and Gray Luvisols) of Prince Edward Island. The acidic (pH 5.0–5.8) soils, varying in texture from loam to loamy sand, had an organic C range of 0.75–2.74%. Both mineral N flush (4–38 µg N g^{-1} soil) and the percentage of soil organic N in the mineral N flush (0.4–2.0%) were relatively low compared to other studies. This observation was related to the generally low pH range of these soils. Potentially mineralizable soil N (N_0) ranged from 44 to 247 µg N g^{-1} and accounted for 4.5–13.3% of the total soil organic N. The N_0 was closely related to the mineral N flush ($r^2 = 0.94$) but poorly related to the percentage of organic matter ($r^2 = 0.26$) or organic N ($r^2 = 0.38$). The results indicate that for these soils of similar properties, with low levels of residual mineral N, the mineral N flush could be utilized as an indirect measure of the soil N mineralization potential.

Tillage

Soil tillage requirement and suitability for direct drilling. Studies were conducted to assess the tillage requirement of some well-drained Podzolic and Luvisolic soils in Prince Edward Island and their suitability for direct drilling. Relatively high amounts of silt and fine sand indicated that the soils were structurally unstable with a propensity for compaction. Compactability was inversely related ($r^2 = 0.90$) to concentrations of soil organic carbon over a range of 0.2–2.0%. In the Ap horizons, where organic carbon exceeded 1.6%, the level of macroporosity (equivalent pore diam. >50 µm) was generally greater than 10%. The B horizon and lower level of the Ap horizon, generally, had low porosity and organic matter, although pore continuity was adequate. Macroporosity was closely related to soil bulk density ($r^2 = 0.81$). Penetrometer resistance down the soil profile indicated a relatively shallow rooting depth potential of 25–40 cm. A 3-year direct drilling study with spring cereals illustrated that some degree of soil loosening is required to maintain optimum soil structure. Soil limitations for direct drilling were mainly low resistance to compaction combined with low potential for regeneration of soil structure. The possible implications of the soil physical properties are discussed in relation to the use of direct drilling within the short-term rotational mixed farming systems of Prince Edward Island.

FORAGE AND LIVESTOCK

Forage management and physiology

Water soluble carbohydrates (WSC). Water soluble carbohydrates (WSC) in herbage are known to have beneficial effects on silage quality and nutritive value. It is difficult to make a low WSC forage into quality silage, and 7% of dry matter at the initial time of silage making is considered to be a critical level. A survey with various forage crops grown in Ontario, New Brunswick, and Prince Edward Island indicated a wide range of variation in WSC concentration, from 1 to 20% of dry matter, depending upon crop species, location, climate, and management practices. Most of the samples showed a lower concentration than the critical level, and it appeared that forage crops grown in eastern Canada were generally low in WSC. A field experiment with timothy showed that increasing the rate of N lowered the WSC, and this trend was more pronounced when insufficient K was applied. Application of K generally increased WSC, but when N rate was low, the K treatment resulted in a lower WSC. This influence of P was less than the effects of N or K. To increase WSC content of timothy, it was necessary to apply a balanced fertilizer, such as those with a $N\text{-}P_2O_5\text{-}K_2O$ ratio of 3:1:3.

Nematode survey under sod-seeded alfalfa. The predominant nematode species recovered from experimental sites of sod-seeded alfalfa was the root lesion nematode, *Pratylenchus penetrans*. Foliage yields in aldicarb-treated plots were 25% greater than in untreated check plots, and this response was evident even when the active ingredient (a.i.) application rate was only one-tenth of the recommended rate of 2.24 kg·ha^{-1}.

Direct drilling of alfalfa. Direct drilling of forage species is a fast method of grassland renovation, but the establishment of newly seeded legumes may be adversely influenced by pests. The effects of fenamiphos, heptachlor, benomyl, and methiocarb on the establishment and growth of direct-drilled alfalfa were studied in two 2-year field experiments. In experiment l, alfalfa yields were more than tripled when treated with fenamiphos, and alfalfa density was also increased. Fenamiphos reduced the numbers of root lesion nematodes (*Pratylenchus penetrans*) in the soil and alfalfa rootlets as well as infection of alfalfa tap roots by *Fusarium* spp. In experiment 2, dry matter yields, alfalfa densities, and nematode numbers varied significantly between the two sites. Broadcasting fenamiphos increased total dry matter production and reduced nematodes in the soil more than did a band application. Alfalfa yield was increased by fenamiphos in the post-seeding year at one site. Compared with fenamiphos, benefits from heptachlor, benomyl, and methiocarb in direct drilling of alfalfa were not of practical significance.

LIVESTOCK

Improving the selenium status of grazing animals. Selenium (Se), in the form of calcium selenite, applied to pastures at 0, 10, 20, and 30 g/ha increased the Se content of both the forage and the blood of grazing steers. An Se application rate of 30 g/ha was required to increase the forage Se and blood Se contents to adequate levels.

Supplemental protein for steers fed alfalfa silage. Alfalfa silage diets were supplemented with either soybean meal, fishmeal, or no supplement. Growth rate, feed intake, and feed conversion efficiency of heavy Holstein steers were not affected by these treatments.

Pasture versus feedlot for Holstein steers. Intensively grazed steers on permanent pasture plus annual ryegrass outgained steers on silage plus barley at 2 kg/day in the feedlot (1.3 versus 1.0 kg/day) during the late May to mid-September period. An extended grazing period based on fodder beets or kale produced gains of 1.0 and 0.8 kg/day and permitted pasture management of the animals until 1 December on the beets and 15 December on the kale. Total period daily gains per steer averaged 1.1 kg/day for feedlot, 1.1 kg for pasture–fodder beets, and 1.0 kg for pasture–kale.

POTATOES

Management and nutrition

Urea versus ammonium nitrate for potato production. Urea is increasingly replacing ammonium nitrate in mixed fertilizers due to its lower cost per unit of nitrogen (N) and less restrictive shipping safety requirements. A 4-year study evaluating the implications of replacing ammonium nitrate with urea for potato production was conducted at Charlottetown. When N as urea at 200 kg/ha was banded at planting, urea reduced total tuber yield by 10% in six out of 12 experiments. However, when N was banded at 150 kg/ha, the recommended N rate for potatoes, total yield was reduced in only two of the 12 experiments. Potato growers applying high rates of mixed fertilizers containing urea should consider alternative methods of application for at least a portion of the fertilizer applied, such as broadcasting a portion before planting and banding the remainder.

Bed planting of Kennebec potatoes improves seed production. Maximum production of small whole seed potatoes (under 60 mm diameter) requires high plant populations, which under normal 90-cm row widths means crowding plants in the row. Poor utilization of sunlight occurs until plants expand to fill between the rows. Narrower rows would require extensive replacement of current field equipment designed for 90-cm rows. Planting an extra row between every other pair of rows to form three-row beds between 180-cm wheel tracks would permit higher plant populations with more even spacing of plants in all directions, and still permit use of sprayers and harvesters with 180-cm wheel track widths. Commercial planters for such three-row beds are now available. Such alternating three-row beds were compared with normal rows for Kennebec potatoes at Charlottetown over 4 years at two plant populations. The yields of tubers under 60 mm in these hand-planted plots were increased by 2.0 t/ha at 63 000 plants per hectare and by 3.2 t/ha at 94 000 plants per hectare by using the three-row beds, with no change in yields of tubers over 60 mm. The net seed yields (weight of seed produced minus weight of seed planted) were increased by 1.8 and 3.4 t/ha with the three-row beds at the low and high populations, respectively.

Effect of daminozide on Kennebec and Red Pontiac seed production. Daminozide is known to increase the yield of small whole seed tubers of some European cultivars. However, it is not registered for use on potatoes in Canada. Different rates of daminozide were foliar-applied at different tuber growth stages to field grown seed crops of Kennebec and Red Pontiac potatoes over 3 years. Best results were found when daminozide was foliar-applied at 1.0 kg/ha when the larger tubers had reached about 3 cm in diameter. Daminozide significantly increased both the yield and the number of tubers up to 55 mm in diameter by about 20% (from 10.5 to 12.7 t/ha and from 146 000 to 172 000 tubers per hectare, respectively, for Kennebecs, and from 12.7 to 15.2 t/ha and from 199 000 to 236 000 tubers per hectare, respectively, for Red Pontiacs). Total yields were not affected significantly by daminozide, whereas total tuber numbers were slightly increased. Earlier applications were less effective.

Chitting (greensprouting) of seed potatoes advances maturity and increases production. Chitting of potatoes is the sprouting of seed tubers under warm conditions in the presence of light. Contrary to the long white succulent sprouts produced by tubers kept in the dark, the rather firm green sprouts produced by chitting remain very short (5–15 mm), and compact. Greensprouts better withstand the rigors of planting and in warm soil immediately initiate roots and start to elongate. Chitting of seed is routinely practiced in many European countries to increase the numbers of small tubers in seed production and to advance the maturity of early table market crops.

Field trials compared seed of Kennebec, Sebago, and Red Pontiac cultivars chitted at over 15°C for 3 weeks or more with non-chitted seed planted directly from cool (5–6°C) storage. Chitted seed reached 50% emergence 6 days earlier in four experiments over the 3-year period. Averaged over two planting dates (9 May and 22 May) over 2 years, chitting increased total yields from 19.4 to 24.0 t/ha. Seed size yields (under 60 mm) at 11.0 versus 11.7 t/ha for the chitted seed were not significantly different, but tuber yields (over 60 mm) were significantly increased from 8.4 to 12.2 t/ha by chitting, averaged over the three cultivars. There were no significant interactions between cultivars and chitting.

In a 2-year top desiccation study, chitted and non-chitted tubers were planted in May and top desiccated at either 86 days or 99 days after planting. Averaged over the 2 years, three cultivars, and seed treatments, the later top desiccation resulted in a slight reduction in the under-60-mm yield, from 14.4 to 12.2 t/ha. Chitting increased the yield from 12.6 to 14.0 t/ha when averaged over the years, desiccation dates, and the three cultivars. Yields of tubers over 60 mm increased from 17.5 to 26.7 t/ha with delayed top desiccation, whereas chitting did not significantly affect yield in this tuber size range. Over all, chitting increased total yield from 34.3 to 36.5 t/ha. In this study there were significant differences in the magnitude of the responses to chitting among the three cultivars. For example, responses differed between years and differences in responses occurred between cultivars and top desiccation dates. Sebago gave the best response to chitting over all. The response to chitting is greatest early in the season and diminishes as the tubers enlarge and the crop approaches maturity. Thus, chitting may be useful to seed growers who use early top desiccating or to growers trying to get potatoes early onto the table market.

Pests and diseases

Effect of insecticides on beneficial insects on potatoes. Results of a 3-year field study indicated that foliar sprays of fenvalerate on potatoes did not affect beneficial insects collected in ground traps, when compared with those collected in untreated plots. Likewise, fenvalerate had no more effect on foliage-collected beneficial arthropods than did several other carbamate and phosphate insecticides. Therefore, a buildup of green peach aphids frequently evidenced in plots sprayed with fenvalerate is not likely due to the reduction of beneficial insects. Reproduction of green peach aphids may be stimulated by fenvalerate sprays; however, greenhouse studies have not substantiated this theory.

Nematode survey. Numbers of *Pratylenchus* spp. (primarily *P. penetrans*) were recorded at planting in experimental potato plots over a 9-year period at one location on Prince Edward Island. Tuber yields of Superior and Russet Burbank potatoes in plots treated with aldicarb were compared with yields in corresponding untreated plots. There was a significant linear relationship between the number of root lesion nematodes at planting and tuber yield increases after treatment for Superior potatoes but not for Russet Burbank potatoes. However, when counts were greater than 500 root lesion nematodes per kilogram of dry soil, the tuber yields of Russet Burbank increased in treated plots. Additional trials at other locations and the inclusion of other cultivars are needed to make numerical relationships of this type available to a nematode advisory service.

Potato diseases. Field studies in 1987 included research investigations on cultural and chemical disease resistance aspects of control of fungal pathogens of potatoes. Planting of whole seed resulted in reductions in *Fusarium solani* and *F. sambucinum* damage as compared to use of cut seed. Two potato breeding selections (F79055 and AM6642) and two cultivars (Brador and Dorita) were highly resistant to foliar late blight caused by *Phytophthora infestans*, whereas F71086 was moderately resistant in disease response studies of more than 30 entries. Five treatments of foliar fungicide (chlorothalonil, mancozeb, and metalaxyl) involving protectant–systemic combinations and protectants alone provided acceptable late blight control (about 5% disease damage) as compared to untreated plots with more than 85% defoliation. BAS222 and maneb treatments resulted in about 25% foliar disease. Kennebec seed treatment fungicides evaluated for efficacies of potato wilt (*Verticillium albo-atrum*) control demonstrated disease reductions with CGA449 and RHC376, but these chemicals decreased early plant vigor and plant stand possibly due to phytotoxic effects on cut seed. Cut seed treatments tested for control of *F. solani* on the cultivar Hunter and *F. sambucinum* on the cultivar Sebago generally reduced disease damage, but some fungicides negatively affected early plant vigor (thiabendazole, CGA449, RHC387, RHC377), and metalazyl reduced final plant stands. Control of *Rhizoctonia solani* with seed treatment fungicides applied to Superior was observed as all-improved early plant vigor. Although thiabendazole, mancozeb, pecycuron, pcnb, tolclofos-methyl, and NNF136 resulted in total yield increases, no yield advantages occurred with CGA 449, Validomycin A, iprodione, and thiophanatemethyl.

HORTICULTURE

Brussels sprout cultivar evaluation trials. Results of evaluation trials conducted during four consecutive growing seasons indicate that several cultivars are suitable for production in Prince Edward Island. Captain Marvel consistently produced the greatest yield of marketable sprouts and had a low incidence of internal browning. Acropolis also performed well. Although Valiant ranked sixth in yield, a high percentage of the sprouts were in the most desirable small to medium size range and it was the only cultivar that did not show internal browning. Cultivars Boxer, Mallard, Promethar, and Lunet had the highest incidence of internal browning (0.5–2.2%); therefore they are not recommended for commercial production in Prince Edward Island. In 1985 and 1986, when the plants were grown in seedling trays and transplanted on 11 and 13 June, yields were considerably higher than those obtained in 1983 and 1984, when the plants were field-grown and transplanted on 28 and 29 June.

Tolerance of Brussels sprouts to high levels of boron. Brussels sprouts and other cole crops are considered to be sensitive to boron (B) deficiency. In the central region of New Brunswick, Brussels sprouts have been grown with regular applications of B for the past 20–25 years. Consequently, in some fields there has been some buildup of residual B, which could be detrimental to the production of Brussels sprouts. Field studies conducted near Rogersville, N.B., showed that rates of B as high as 4–8 kg/ha had no significant detrimental effect on the yield of Brussels sprouts. It is concluded that Brussels sprouts can be successfully grown with rates of B up to 4 kg/ha. Such fields can safely be followed by cereals or by any other crop sensitive to B toxicity, since the residual effect of B was found to be short-lived on the investigated New Brunswick soils. However, it is recommended that B not be applied at a higher rate than 2 kg/ha; this rate should eliminate B deficiency in most crops.

Onion keeping quality. A 3-year study with 21 onion cultivars was conducted to determine the association of fructan with the keeping quality of onion bulbs at 4°C. Most of the onion bulbs were stored successfully for 2 months, and 30% of the top five cultivars were marketable after 4 months of storage. Gel exclusion chromatography revealed that all onion cultivars contained monosaccharides, sucrose, and fructan with a degree of polymerization (DP) of 3.

Cultivars with a keeping quality of 2 months or longer contained an additional series of fructan with a DP varying up to 8. Cultivar Buffalo that was storable for less than 2 months contained little or no fructan with a DP of 4 or higher. A high correlation was found between the keeping quality and the concentration of fructan with a DP of 4 or higher.

Lowbush blueberry cultivar trial. Sixteen superselect lowbush blueberry clones were set out in 1981. The third harvest was taken in 1987 when yields of Augusta and selections 70-27 and 70-28 were greater than 10 t/ha. Augusta produced the largest fruit.

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R.F. Kelly, B.Sc. End of specified term employment 30 September 1987	Food technology
F.W. Calder, B.Sc.(Agr.), M.Sc. Retired 15 January 1987	Superintendent; Forage crops

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INTRODUCTION

The Kentville Research Station conducts a comprehensive research and development program, which is focused on the horticultural, poultry, and cereal additives of the agricultural industry in Atlantic Canada. The research is multidisciplinary and encompasses genetic improvement, nutrition, and management as well as the protection of economic crops from insects, diseases, and weeds. Increasing emphasis is being placed on the research and development needs of the food processing industry through development of innovative technologies to extend the shelf life of products as well as improvements in process technology. The extension of the effective marketing season for domestic fruit and vegetable produce is also being stressed through innovative storage research. Management of livestock and their related feed crop requirements are studied extensively at the Nappan Experimental Farm. Emphasis is on the beef cow–calf, sheep, and swine production systems.

The research results reported herein are intended to provide an overview of current studies and progress achieved. More complete information may be obtained in the annual research reports of the two establishments by writing to the Research Station, Research Branch, Agriculture Canada, Kentville, N.S. B4N 1J5, Tel. (902) 678-2171; or the Experimental Farm, Nappan, N.S. B0L 1C0, Tel. (902) 667-3826.

G.M. Weaver
Director

BERRY CROPS

New lowbush blueberry cultivar introductions. Two new cultivars were named in 1987: Fundy (tested as 69-1) and Cumberland (tested as 510). Fundy is a vigorous cultivar with strong, erect sprouts reaching up to 40 cm in height. Yield is medium to high and fruit is very large, with the largest berries exceeding 1 g. Fruit has a heavy bloom, and fresh flavor is rated as good. The fruit of Fundy is borne high on upright stems, making hand-harvesting efficient. Cumberland exhibits a moderate sprout growth of up to 25 cm. Yield is medium to high, similar to Augusta and Chignecto. Fruit size is medium, larger than Chignecto but smaller than Augusta, with a light bloom. Fresh and frozen flavor is rated as very good.

Strawberry breeding. Twenty-four strawberry seedlings were selected for further testing from 3200 seedlings that had been screened for resistance to *Phytophthora fragariae* Hickman, before planting in 1986. The cross K80-23 × Allstar was notable in that it produced seven selections with very large fruit that were mid-season to late in ripening. In 1987, selection K83-4 (Glooscap × Annapolis) performed very well in a trial containing seven clones, when compared to the red-stele-resistant standard cultivar, Cornwallis. K83-4 ranked first in fruit size and second in yield after Kent. K83-4 was mid-season in ripening and sustained less post-harvest fruit rot than Kent. Extensive testing of K83-4 is under way throughout the Atlantic region.

TREE FRUITS

New tree fruit cultivars

Korona apple. Bred in 1952, Korona has been released after second testing since 1976 as a mid-early season cultivar of the McIntosh type, particularly suited to the U-pick trade and for home gardeners. The fruit is of good size, is a bright attractive red, and has good flavor and texture. Because the tree is only moderately vigorous and crops well and regularly, Korona will be especially adapted to situations where these attributes are important.

Oberle apple. Received in 1974, Oberle has been released after second testing since 1981 as a very early, attractive apple of exceptional size and quality for its season. The tree is somewhat compact, is precocious, and sets a good crop annually. Oberle was bred by the late Dr. George Oberle of Virginia Polytechnic Institute (VPI), Blackenburg, Va. It is a joint release with VPI and is named in honor of its originator.

Dave's Delight pear. Bred in 1962, Dave's Delight has been released after observation since 1973 as an early season, attractive, high-quality pear, which stores well for its season and is relatively free from core breakdown. The tree is moderately vigorous, relatively precocious, and productive. Although the fruit tends to be relatively small, the high-quality, attractive appearance, and good handling characteristics of Dave's Delight will give another type of snack fruit to complement plums, peaches, and early apples in late summer.

Development of new apple rootstocks

Progress toward the introduction of the new KSC apple rootstock candidates has been achieved through a long-term field study and laboratory evaluation of root hardiness with McIntosh and Red Delicious. At 9 years of age, McIntosh trees on some of the selections exceeded yields of 220 kg per tree (84 t/ha). Red Delicious yields were much lower regardless of the rootstock, and the three highest-yielding rootstocks averaged 132 kg per tree (50 t/ha). Vigor differences between the stocks are extensive. Selection KSC-28 is one of the most dwarfing at approximately 55% of the largest. This stock has also exhibited superior precocity with both cultivars. In a separate trial, root hardiness of KSC-3 was compared with 19 other apple rootstocks and found to be more hardy than most malling stocks. Further root hardiness evaluation studies are under way and positive results are needed prior to release of this material to commercial orchardists.

Growth regulators' effect on Clapp's Favourite pears

Daminozide, chlormequat, and paclobutrazol were compared for their effectiveness on growth and fruiting of Clapp's Favourite pears. The paclobutrazol was applied to the soil in a water drench in November 1983; the other two growth regulators were applied to the foliage in the spring of 1984. Terminal growth was reduced by daminozide and chlormequat in the year of treatment and suppressed by chlormequat and increased by paclobutrazol the following year. The number of flower clusters per limb was increased by daminozide. All growth regulators reduced average leaf area and fruit stem length. Fruit length was reduced by paclobutrazol and average fruit weight was reduced by daminozide and paclobutrazol. The growth regulators did not affect flesh firmness, soluble solids, or yield.

PROTECTION OF CROPS AGAINST PESTS

Insect pests

Control of corn borer and corn earworm. Granular Dipel reduced European corn borer populations 50%, but it had no significant effect on the yield of grain corn. Corn earworm adults have been discovered in large numbers feeding on the nectar of cruciferous plants. By placing attractant traps in these areas, corn growers can apply insecticides more effectively for better control with less material.

Blueberry maggot inspection method. The presence of maggots in shipments of lowbush blueberries for fresh fruit markets can easily be determined by the immersion of crushed berries in a 17.5% brown sugar solution; the maggots float to the surface. This method of examination requires about 20 min for a 0.57-L (1-pint) sample and 30 min for a 1.14-L (2-pint) sample, and takes less time than the current method of stewing, sieving, and diluting the juice with water.

Advantages and biological costs of using synthetic pyrethroids in Nova Scotia apple orchards. A 4-year (1980–1983) study of 132–175 orchard blocks in the Annapolis Valley indicated the advantages of using synthetic pyrethroids (SPs) compared with conventional organophosphate (OP) insecticides. Injury by winter moth and fruit-stinging mirids was lower in SP blocks than non-SP blocks and SP blocks had fewer second generation mines of the spotted tentiform leafminer (STLM). In 1980 and 1983, the percentage of fruit injured by insects was lower in the SP blocks than in the non-SP blocks. Blocks treated with SPs in 1980 needed fewer insecticide applications in 1981 than blocks that had not received SPs in 1980. SP use also had biological costs. Higher counts of STLM mines were sometimes associated with use of the SP, fenvalerate, or multiple SP applications the previous year. SP use was also associated with increased densities of the European red mite (ERM) and apple rust mite (ARM), increased leaf bronzing by ERM and ARM, and more frequent miticide applications by growers. Fenvalerate was more frequently implicated than permethrin because fenvalerate is more toxic to the predatory mite, *Typhlodromus pyri* Scheutem, and it has longer residual activity in orchards.

North American distribution of *Coccinella septempunctata* (Linnaeus) (Coleoptera: Coccinellidae)

The Palaearctic sevenspotted ladybeetle, *Coccinella septempunctata* Linnaeus, well established in North America, has now spread through parts of five Canadian provinces and 34 contiguous eastern states of the United States. In southern coastal Delaware in June 1984, a mass appearance of *C. septempunctata* occurred where wind systems dropped them into seawater. Large numbers washed up onto beaches, and some surviving beetles annoyed vacationers; a few inflicted bites on people. Similar occurrences have been observed on marsh and beach areas in Prince Edward Island and northern Nova Scotia. It is believed young maturing adults become airborne shortly after nightfall and are carried by low-level nocturnal winds for short distances over bodies of water, ocean, or large lakes where they are deposited when the winds slacken.

Origin of the North American establishment. In considering the locations of the first known discoveries of *C. septempunctata* Linnaeus, in North America, that is, New Jersey and the southern St. Lawrence River, one hypothesis is that there were transoceanic freighter movements in both areas. A second hypothesis is the liberation of adults from Nova Scotia to Florida beginning in 1958 through 1969. Both hypotheses are plausible and neither one is testable. Once established in the two areas, masses of adults were moved by low-level winds, generally northeastward.

Sixth instar larvae of *Noctua pronuba* (Linnaeus) (Lepidoptera: Noctuidae)

The sixth instar larvae of *Noctua pronuba* (Linnaeus), although similar to the other nuctuinae genera, can be distinguished by the hypopharyngeal complex and mandible morphology. Life history notes based on larvae and adults collected in Nova Scotia are also given.

An isolating mechanism between *Ixodes dammini* Spielman and *I. seapularis* Linnaeus

Ixodes seapularis, the dominant pest tick in Florida, is present north to Maryland along the Atlantic coast, and *I. dammini* is present from New Jersey to Massachusetts. Both species are carried by northward spring-migrating birds. *I. seapularis* has been found on the eastern end of Long Island, N.Y., and *I. dammini* has been found in western Nova Scotia, although there is no indication of an established population in Nova Scotia. In the south, *I. seapularis* has had an annual generation. *I. dammini* in the north has a generation time of 1.5 years. The nymphal stage of *I. dammini* is 50% longer than that of *I. seapularis*. The difference in the nymphal molting time and in the presence of a spring breeding period can serve as geographic and temporal isolating mechanisms between these species.

Regulation of *Dermacentor variabilis* (Say) by limited dispersion of larvae from the egg mass (Acari: Ixodidae)

Dermacentor variabilis larvae are unable to move more than 2.5 cm from site of egg mass deposition. Because the gravid female is immobile at the time eggs are produced, the newly emerging larvae are highly dependent on a small mammal passing through the limited area for a blood meal and survival.

Age effect analysis of Dermacentor variabilis (Say) adult populations during seasonal activity (Acari: Ixodidae). The age effect, as measured by survival under modest water deficit stress of adult *Dermacentor variabilis*, reveals the history of previous questing activity. This method can be used for an age analysis of the population where low density prevents the use of the mark and recapture technique for population estimation.

Plant pathology

Resistance of Venturia inaequalis (Cke) Wint., in sterol inhibitors. The efficacies of sterol biosynthesis inhibiting (SBI) fungicides have been evaluated for the control of apple scab at the Kentville Research Station for several years. The SBI fungicide, bitertanol, was first introduced in a test orchard in 1978 and tested each year thereafter. Efficacy of bitertanol began to decline in 1984 and by 1987, complete loss in disease control occurred with this fungicide. Isolates of *Venturia inaequalis* were assayed against increasing concentration of bitertanol in agar media, beginning in 1984. The minimal concentration necessary to inhibit mycelial growth of sensitive isolates was <1.0 µg/mL, but minimal inhibitory concentrations ranged from 3.0 to 5.0, 1.2 to 9.8, 1.0 to 13.0, and 6.0 to 12.0 µg/mL for isolates obtained in 1984, 1985, 1986, and 1987, respectively. Resistant isolates also showed cross-resistance to other sterol inhibitors. This is the first occurrence of complete loss in apple scab control resulting from resistance to an SBI fungicide.

Effect of applying fungicides for scab control after a frost. Spartan and McIntosh apple trees that had been sprayed with Phygon on the day of a frost were significantly more russetted than those sprayed with Captan. The results indicated that Phygon should not be applied to apple trees on the day of a frost and that the present recommendation to delay Phygon applications for 5 days after a frost is sound.

Apple replant disease. Treating apple replant problem soil with baking soda increased the growth of Beautiful Arcade seedlings in soil from between trees, but decreased growth in soil from old tree sites in a greenhouse pot trial. Mixing the site soil prior to planting, and soil treatments of Captan, Manzate 200, Basamid, or the Vydate L annual treatment at petal fall gave the greatest trunk cross-sectional area of McIntosh apple trees planted in a replant problem site.

Frost injury of vegetative buds of lowbush blueberry. A condition of lowbush blueberry has been observed periodically in which the apical meristem and innermost leaves of vegetative buds turn dark brown and die. Subsequent growth results in a rosette consisting of the blackened centre surrounded by a few expanded leaves that previously were the outermost leaves of the bud. This type of growth is in contrast to that from unaffected buds, which develop normally into long (6–10 cm) shoots consisting of 8–14 leaves. The consequence of this disorder is that there is less vegetative growth to support fruit production. Based on field observations, it was suspected that this disorder was related to frost. When blueberry plants with expanding buds were subject to −2.0°C for 0.5 h or longer in a controlled environment, identical symptoms to those in the field were induced. Differences were not observed among seven clones tested. Blueberry plants are usually considered to be sensitive to frost during bloom, but these observations indicate that injury may also occur prior to bloom during early stages of development in spring.

Pesticide chemistry – insects and weeds

Pyrethroid insecticide. The broad spectrum pyrethroid insecticide, permethrin, when applied to apple trees in July for codling moth, *Laspeyresia pomonella* Linnaeus, control also resulted in control of winter moth, *Operophtera brumata* Linnaeus. Permethrin residues persisted throughout the growing season on leaf, bark, and orchard soil under the tree canopy. Fall emergence of adult winter moth from the soil was reduced, consistent with control due to the presence of soil, soil litter, and/or bark permethrin residues.

Guthion residues and blueberry maggot control. Variation in residues of Guthion obtained in lowbush blueberry fields following aerial spray of the organophosphate soil insecticide, phorate, and the triazinone herbicide, metribuzin, which resulted in increased phytotoxicity in soybean, indicated increased soil phorate residues when both chemicals were applied.

An interaction between the triazinone herbicide, metribuzin, and the herbicide synergist, tridiphane, was demonstrated in metribuzin tolerant and susceptible cultivars of soybean and tomato.

STORAGE

Effects of storage atmosphere and humidity on McIntosh fruit quality

Storage of McIntosh apples in high humidity in 0.5% CO_2 plus 1.0% O_2 (low oxygen (LO), 3°C) atmospheres decreased epidermal resistance to ethane diffusion but did not affect internal ethanol content. Storage of fruit in LO decreased internal CO_2 and increased O_2 levels as compared to fruit held in 5.0% CO_2 plus 3.0% O_2 standard controlled atmosphere (SCA). Fruit firmness of McIntosh apples stored in either SCA or LO determined after storage for 7 days at 20°C, increased with storage humidity over three crop years. LO atmospheres consistently resulted in fruit firmer than that from SCA over the three crop years. Titratable acids were higher in fruit stored in LO as compared to similar fruit stored in SCA, but they were not affected by storage humidity over the 3-year study. The incidence of senescent disorders in SCA was eliminated by storage in LO. High storage humidity in SCA (98–100% relative humidity (RH)) increased the incidence of senescent disorders and decreased the incidence of low oxygen not generally affected by storage atmosphere or humidity.

Effects of storage temperature, humidity, and duration on the quality of ostrich fern, Matteuccia struthiopteris (L.) Tod. Storage of ostrich fern at temperatures above or below 0°C decreased storage life and marketable quality. Relative moisture content, weight loss, ascorbic acid content, bacterial load, yeast, and mold loads generally increased proportionately with increased storage temperature above O°C and duration. Ostrich fern absolute moisture contents decreased with extended storage at lower storage humidities. Marketable yields decreased with higher storage temperature, lower storage humidity, and extended storage duration. Optimum storage conditions of 0°C and 100% RH provided marketable yields of 94.9% and 76.2% after 16 and 32 days, respectively.

FOOD TECHNOLOGY

Modified-atmosphere packaging

A preliminary assessment of modified-atmosphere packaging (MAP) technology for the maintenance of quality of tray-packed fresh wild blueberries identified two packaging films of moderate permeability to CO_2 and O_2 as being suitable for preventing off-odor and off-flavor development and preserving high yields of percent marketable product. This result was, however, dependent upon the maintenance of low temperatures, 0°C being superior to 5°C, and high quality in the initial berries. Adequacy of packaging equipment to ensure complete flushing of packages with the selected gas mixtures was also an essential prerequisite for successful MAP application.

With regard to nonrespiring food products, the shelf life of refrigerated fresh pasta was extended from a 21-day maximum for the conventionally packaged product to 45 days for MAP (50–75% CO_2:balance N_2 within DuPont Sclairfilm LP 920) product held at 5°C. If the storage temperature was further reduced to 0°C, a shelf life of 60+ days became possible. Simulated temperature abuse (10°C) negated any benefit from MAP.

Both studies have emphasized the requirements for high quality in raw materials, good manufacturing practices, and attention to temperature control during storage and distribution if any benefits of MAP are to be fully realized.

Fruit juice processing

Three methods of improving juice extraction efficiencies were investigated including modification of cheese depth, use of hard apples as press aids, and the use of macerating enzymes. Decreasing the cheese depth increased the yield but lowered the overall capacity of the press unit. The addition of hard apples to soft apples had an interactive synergystic effect on the total juice yield, provided the hard apple proportion exceeded 50%. The results of tests on the effect of three pectic enzyme types on juice yield from air-stored McIntosh apples, under varying conditions of process time and temperature, enzyme concentration, and mass aeration are being analyzed and are expected to eventually define the optimum extraction regimens in relation to initial apple quality.

Trials have also been conducted on a small industrial-scale continuous centrifugation system to determine the predominant factors in the raw fruit material, which subsequently affects the rate and efficacy of juice clarification. Increased times of air storage for McIntosh apples reduced clarification efficiencies with a concomitant increase in sediment volumes. However, enzyme treatment of either the pre-press mash or the post-press juice removed these difficulties and, in the case of mash treatment, actually improved the final clarified juice yields. The effects of an additional pretreatment with flocculating agents on clarification efficiency are under investigation.

Cider fermentation

Over the past two seasons, laboratory-scale fermentation trials have been conducted on a total of 57 varieties of apples (34 names, 23 experimental) to test their suitability for producing high-quality ciders and to define the processing conditions most suited to locally grown produce. Overall, the most consistently acceptable cider quality was achieved from sulfited and depectinized juices that were ameliorated with cane sugar to 16° Brix and fermented to 6–8° Brix at 18–20°C with *Saccharomyces uvarum*. Subsequent treatment included sterilizing filtration, mild bulk carbonation using a 150-kPa overpressure CO_2

at 0–2°C, and aging for 6–9 months at 15°C. Taste panel evaluation, even using a simple hedonistic technique, proved difficult due to the wide variety of sensory characteristics among the ciders and the general present-day unfamiliarity and inexperience with cider evaluation among panelists. However, a general preference for ciders displaying a clean and fruity but unobtrusive flavor was apparent, with marked acidity, astringency, or bitterness resulting in inferior scores.

Sensory evaluation

An essential component of a food research program is the continuous availability of a group of trained sensory panelists. Such a permanent sensory panel was established at Kentville during 1987. Eighty persons were recruited from the surrounding community through newspaper advertisements, and interviews were subsequently conducted to determine their frequency of availability, previous sensory experience, dietary restrictions, and adventurous spirit in eating habits. Individual abilities were further screened using tests for keenness of perception of basic taste sensations, multiple comparison trials, product attitude tests, and color aptitude and color blindness evaluations. Sixteen persons were eventually selected to form a pool of sensory panelists.

The sensory panel has subsequently been involved in initiating definition of the quality criteria of fresh produce having significance in determining the acceptability of a particular product to the consumer. For example, using 29 varieties of strawberries, the following set of descriptors were developed: *external appearance* of soft to firm, light to dark red, dull to bright, flat to glossy, uniform to nonuniform in color, and slightly to extremely seedy; *internal appearance* of light to dark red and visible to non-visible core; *flavor* of slight to extremely sweet, tart, astringent, melon-like, apple-like, honey-like, musty, and bitter; and *texture* of uniform to nonuniform, soft to firm, dry to juicy, slightly to extremely seedy, and soft to firm core. Definitions of these descriptive terms were developed and sample preparation methods and reference materials selected.

ORNAMENTALS

Growth regulator and lighting effects on hybrid lilies

The effects of A-Rest and Paclobutrazol (Bonzi) on height control, growth, and flower formation in hybrid lilies grown as pot plants were investigated. A secondary objective of the work was to determine the effect of declining or increasing light levels on growth. Cultivars investigated were Enchantment, Prominence, and Connecticut King. Paclobutrazol proved unsatisfactory for height control in Enchantment and Prominence. A-Rest spray (with active ingredient (a.i.) of 0.25 mg per pot) provided the best compromise between height control and lack of lower leaf senescence in those cultivars. Connecticut King proved to be the cultivar most suitable for pot plant production. In this case, effective height control and good plant quality were obtained with A-Rest spray or pot drench (with a.i. of 0.33 mg per 10-cm pot). All plants grown in declining light levels produced fewer flowers, lower flower weights, and longer stems than those grown under increasing light levels; however, these differences were not sufficient to seriously jeopardize production under late fall and winter conditions.

Influence of root and shoot zone temperature on growth, flowering, and 14-carbon assimilate partitioning in chrysanthemums grown in nutrient film

Flowering chrysanthemum cultivar Polaris was delayed at 12°C as compared with 16°C night air temperature (constant day temperature: 21°C) irrespective of root temperature. Increasing root temperature from 12 to 20°C improved plant and flower weight at both night air temperatures, but a further increment to 28°C had less effect. Night air temperature had a significant effect on stem length with plants grown at the lower temperature showing the greatest stem growth. Stem length was seriously restricted at 12°C root temperature. Carbon partitioning to developing further flower buds was not signficantly affected by root or shoot temperature, whereas partitioning to the roots was slightly retarded at

12°C root temperature. Raising root zone temperature in chrysanthemum does not mitigate the effects of suboptimal air temperatures on growth and development.

Top and capillary irrigation: Effect of controlled release fertilizer placement in Andorra juniper

Andorra juniper (*Juniperus horizontalis* 'Plumosa compacta') plants in 4.5-L containers gained more dry weight and showed greater seasonal branch growth when a slow-release fertilizer (Nuticote 16-10-10 type 100) was incorporated into the medium at a rate of 5 kg/m^3 than when an equivalent quantity of fertilizer was applied to the surface of the containers. Plants growing in fertilizer-incorporated media, maintained on a gravel standing ground and top irrigated (8 L of water per week; GINC), showed greater dry weight gain than those in similar media on a sand capillary bed (CINC). Capillary-irrigated plants with surface-applied fertilizer and hand-irrigated plants with surface-applied fertilizer showed less seasonal branch growth and less dry and fresh weight gain than the plants growing in the fertilizer-incorporated media. Plants irrigated with 8 L of liquid fertilizer (15-15-18 Plant Products Ltd., Bramalea, Ont.) with N at 200 ppm showed similar growth to the CINC treatment and slightly inferior growth to the GINC treatment.

Tissue nitrogen concentration (determined on samples of green, nonwoody tissue harvested at planting in late May and again in late June, July, August, and September) varied with treatment. A composite sample taken from 12 plants at the time of planting revealed an N concentration of 1.18%. Concentration had increased in all plants by the sampling date in late June, but the greatest increase was observed in plants given the GINC treatment. By late July, N concentrations had risen in all treatments. Concentrations remained stable through August, but by late September they had risen to seasonal maxima in all treatments except GINC. There was a significant, positive correlation between late June tissue N concentration and total seasonal growth.

ANIMAL SCIENCE

Poultry

Effects of light source, ambient temperature, and dietary energy source on the general performance and incidence of leg abnormalities of roaster chickens. Light source (incandescent versus fluorescent) had no significant effect on mortality, body weight, or feed conversion of roasters. Incidence of angular deformity (AD) and total leg abnormalities (TLA) was lower and tibial dyschondroplasia (TD) was higher for roasters reared under fluorescent as opposed to incandescent light. Lower ambient rearing temperatures (4.5, 3.0, or 1.5°C) increased the incidence of mortality, curly toes (CT), AD, enlarged hocks (EH), and TLA but resulted in a decrease in TD and had a detrimental effect on feed conversion. Increasing dietary energy resulted in a linear improvement in feed conversion. Increasing dietary energy resulted in a linear increase in monetary returns.

Interrelationships among lighting, ambient temperature, and dietary energy and broiler chicken performance. Lighting (green fluorescent versus incandescent) and ambient temperature (4.5, 3.5, and 2.0°C) treatments had no significant effects on mortality, feed conversion, body weight, or monetary returns. The highest dietary energy regimens resulted in the heaviest body weights, best feed conversion ratios, and the highest monetary returns. Low temperatures had a depressing effect on broiler chickens fed low energy diets.

The effect of adding white fish meal containing enzyme digested or untreated stickwater solids to diets for broiler chickens. Diets containing white fish meal (FM) with stickwater solids that had or had not been digested with the proteolytic enzyme Alkalase had no effect on the incidence of mortality, 42-day feed conversion, or percentage of Grade A carcasses. Except for the weight of males at 21 days, the addition of enzyme-treated stickwater concentrate tended to reduce live weights for males at 42 days and monetary returns, but the addition of enzyme-treated stickwater concentrate improved 21-day feed conversion.

Effects of altering the calcium, phosphorus, sodium, potassium, and chloride content of diets for broiler chickens. High dietary K (1.23%) increased mortality (22–42 days), high available phosphorus (aP) (0.57%) increased weight gain between 0 and 21 days, and high dietary calcium (Ca) and high dietary K both reduced overall (0–42 days) feed conversion. In general, high levels of all cations and anions in combination gave extremely wet excreta. Feeding high levels of dietary Ca or K reduced the incidence of mild dyschondroplasia of the metatarsus and mild tibial dyschondroplasia (TD), but high dietary chlorine (Cl) increased the incidence of severe TD.

Effect of dietary cation–anion balance and calcium content on general performance and incidence of leg abnormalities of broiler chickens. Body weight gain and feed conversion were affected by the dietary content of K, Ca, and Na and also by their interaction. Increasing dietary K or Na increased litter moisture, whereas Cl moderated the effect of Ca. The incidence of TD was reduced by increasing dietary Ca, Na, or K, but their effects are interdependent on each other and on the level of dietary Cl. Dietary Ca level changed both the pattern and response of birds for growth and feed utilization, suggesting that the term meq kg^{-1} (Na + K − Cl) is an inadequate measure of dietary cation–anion balance.

Effect of dietary cation–anion balance on acid-base status and incidence of tibial dyschondroplasia of broiler chickens. The cation–anion balance of the diet fed affected the acid–base balance of the blood – the effect of K on PO_2 and HCO_3 of venous blood was interdependent of the dietary level of Ca and Cl. The incidence of tibial dyschondroplasia (TD) decreased with increases in dietary Na and K. Increasing dietary Ca to 1.38 reduced TD but the effect was interdependent upon the dietary level of Na, K, and Cl. Metabolic acidosis produced by manipulation of the cation–anion balance (Na + K − Cl) of the diet increased, whereas metabolic alkalosis decreased with incidence of TD.

Effect of dibasic calcium phosphate (ad libitum) and feed texture on the general performance and incidence of leg abnormalities of roaster chickens. Dibasic calcium phosphate ad libitum resulted in increased Ca and phosphorus (P) intake, reduced Ca to P ratio, reduced body weights (at 21 days only), higher overall mortality, and higher incidence and severity of tibial dyschondroplasia (TD) and total leg abnormalities. Roasters fed pelleted grower and finisher diets were not only heavier (at 51 days only), but they had a higher incidence and severity of TD and a mortality due to sudden death syndrome (SDS) compared with mash-fed birds.

Parental effects on performance of broiler chicken progenies. Mortality among broiler progeny from a meat-type parent population consisting of four maternal genotypes (two normal and two dwarf) mated with two normal paternal genotypes and fed three different breeder diets was not affected by genotypes or parental dietary treatments. The progeny from normal hens were heavier, had a better feed conversion to 21 days, and yielded higher monetary returns than those from dwarf hens. Parental diets had no effect on progeny weights, feed conversion, or monetary returns.

The effect of feeding a diet containing canola meal on the incidence of fatty liver syndrome among four maternal poultry meat breeder genotypes to 266 days of age. Performance data revealed that adult maternal meat breeders fed diets incorporating 15% canola meal experienced a significant increase in mortality attributed to fatty liver syndrome (FLS) compared with maternal breeders receiving diets without canola meal. Dietary protein levels per se had no significant effect on the incidence of FLS.

Effect on shell strength of feeding supplemental sources of calcium to adult laying hens given insoluble grit during the rearing period. An experiment was conducted to determine the separate and combined effects of giving insoluble grit during the rearing period and small or large particle size (0.3 mm and 3–8 mm in diameter) limestone or oyster shell, as extra sources of calcium during the laying period. The extra sources of calcium resulted in improved shell strength but, overall, grit-supplements during the rearing period did not affect either eggshell strength during the last quarter of the laying period.

Beef

Cow–calf management systems. A 3-year experiment has been completed where systems were compared to more efficiently produce weaned calves. Using 84 cows, we evaluated the effects of calving season (November, March, June), summer pastures, and winter feeds on the productivity of these systems. Based on the conditions and limitations of our study, we concluded that the best system used cows calving in late spring, grazing well-managed permanent pastures, and fed adequate but low-cost winter silages. November-born calves were the heaviest at weaning, but the June calves were finished at the earliest age.

Culled cows. A 2-year study was initiated to study the effects of grain feeding of 48 culled cows. Young (30 months or less), intermediate, and old (5 years or more) cows were fed 0, 28, 56, 84 days on a high barley ration and forage. Our results showed no economical advantage in feeding culled cows, as the feeding costs exceeded the extra revenues. The young cows tended to grow, whereas the older ones became fatter. Age was a detrimental factor for carcass and meat characteristics. Grain feeding had no significant effect on the carcass quality of the beef produced.

Pasture. A 3-year comparison was completed on three pasture species mixtures of white clover–red fescue, Kenhy tall fescue–white clover, and Kenhy tall fescue–birdsfoot trefoil. Our results were excellent with average gains of over 1 kg/day, gains per hectare of 800 kg, and over 600 animal-grazing days per hectare. The white clover pastures resulted in the best animal gains, whereas the Kenhy tall fescue brought about more total grazing days due to more dry matter per hectare. The hand separation of the dry matter in 1987 pointed out that species changes had occurred when compared to seeding rates.

Alfalfa silage. In 1987 we harvested silages made from an alfalfa–brome mixture, a weeds–alfalfa crop, a mature alfalfa stand, and silage corn. These silages with or without barley at 1 kg/day were fed to 40 steers. Our data showed that overly mature alfalfa is not productive, resulting in reduced gains, silage dry matter intakes, and poor digestibility coefficients. The weeds–alfalfa brought about as good performances as the alfalfa–brome but still less than the silage corn. Grain feeding was beneficial in all cases, as the gains were only adequate (0.8 kg/day) on silage alone.

Fish meal. Forty-five crossbred replacement heifers were fed hay plus 2 kg/day of one of five grain mixtures composed of barley, soybean, and fish meal. The proportion of soybean and fish meal varied from zero to 100% of the supplemental protein to produce a 15% protein grain ration. Our data showed a small advantage in using fish meal up to 180 g/day. Higher intakes of fish meal were still economical but did not result in better growth performances compared to soybean meal. Fish meal did not cause any problems in intake and was readily accepted at all levels.

Sheep

Maedi-visna. Promising results have been achieved in the two control programs that were undertaken to regulate the transmission of the maedi-visna virus. Over the 4-year period, the flock that was established by artificially rearing ovine colostrum-deprived lambs has continually tested negative for the antibodies to the maedi-visna virus. Ewes on the "test and remove" program, which involved routine serologically blood testing and the removal of positive maedi-visna reactors and their progeny, have not had a positive maedi-visna reactor detected for the past 18 months. Blood samples were analyzed by the agar gel immunodiffusion test at the Animal Pathology Laboratory in Sackville, N.B.

Fecundin. A field trial was done to evaluate the use of the sheep twinning vaccine *Fecundin* (androstenedione 7-HSA in a deae-dextran adjuvant) as a method of improving prolificacy in a commercial crossbred flock. A 13% improvement in prolificacy occurred among the *Fecundin*-vaccinated ewes. The improvement in prolificacy was primarily achieved by the increased incidence of triplet births.

Swine

Fish silage on meat quality of pork. Diets containing 10% low fat fish silage must be removed from the diet of pigs 20 days prior to slaughter to avoid off-flavors in pork. Long-term frozen storage of fish silage-fed pork resulted in no premature oxidation as compared to control samples.

Short-term feed restriction on age at puberty and ovulation rate at first, second, and third heat in gilts. Short-term (4 days) severe feed restriction of gilts beginning at age 165 days had no effect on age at puberty. Ovulation rate appears unaffected by cycle number in gilts. Litter size of gilts bred at first, second, or third heat appears to be affected by uterine capacity or maturity.

Hull-less oats good feed source for pigs. Levels as high as 97% hull-less oats in diets for growing-finishing pigs result in growth performance and feed conversion better than conventional diets. Problems with overfat carcasses at slaughter from pigs fed high levels of hull-less oats may be caused by the high energy of the product.

Canola meal in corn-based diets. Levels as high as 30% canola meal in growing pig diets containing National Research Council energy levels have no detrimental effects on growth performance, feed consumption, and carcass quality. Levels of canola 20% and above appear to hinder feed conversion in low energy, corn-based diets.

Cereal cultivar testing. There were 60 cultivars of barley tested at Nappan in 1987. Helena, a German cultivar, and Albany, a recently released Charlottetown cultivar, were the two top performers in the two-row test. In the six-row test, there were a few promising cultivars but none ready for licensing as yet. There were 53 cultivars of spring wheat tested at Nappan in 1987. The cultivar Messier was the highest yielding at Nappan but did not perform well at other test sites. Some newer lines of oats were better yielding than Laurient; however, this was the 1st year they were tested and hence need further evaluation (60 oat cultivars were tested). Of the 20 cultivars of winter wheat-winter triticales tested at Nappan, the winter triticales OAC Trillium and GWT 85-21 were far superior in yield to the winter wheats; however, they were more susceptible to lodging. Newer lines of spring triticales were superior with regard to yield to currently licensed cultivars. Maturity and fusarium are still the biggest problems with the spring triticales.

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Departures

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G. Farrell, B.Sc., Ph.D. Completed National Research Council visiting fellowship April 1987	Potato tissue culture

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INTRODUCTION

Fredericton Research Station conducts research on potato breeding, potato pest management, animal and crops, engineering, horticulture, and soils. Research at Senator Hervé J. Michaud Experimental Farm serves the horticultural industry of the southeast coastal region, conducting experiments on cultivar evaluation and management practices for vegetables, berry and tree fruits, cereals, and forage crops.

The potato breeding program at Fredericton serves as the national breeding program for Canada, and focuses on the production of improved parental lines that can pass to their progeny superior quality for the production of french fries and chips as well as for the fresh market. Ancient Andean potato varieties and wild potato species from central and south America are used to create parents with high levels of resistance to diseases.

Research in the Potato Pest Management Section includes the identification and management of potato diseases, the production of antiserum and the development of serological methods for detecting viral and bacterial disease, and the development of disease-forecasting models. Research on insects includes ecology and control of potato pests, insect–plant interactions, and evaluation of the effectiveness of insecticides.

Research in the Animal and Crops Section is directed toward the nutrition and management of dairy and beef cattle. Researchers at Fredericton also evaluate cereal, forage, and corn cultivars to make efficient use of locally produced feeds. Under the agri-food sub-agreement of the economic regional development agreement (ERDA), a technology development program has been undertaken that focuses on livestock feed, the livestock industry, and horticulture.

Soil research is aimed at improving the agricultural land base through finding solutions for soil-related problems in the region. Research is directed to the development of technology to improve drainage and to prevent erosion. Horticultural research involves the evaluation of apple and strawberry cultivars, management of these crops, and studies on winterhardiness. The Agricultural Engineering Section deals with the development and improvement of agricultural machinery and more efficient on-farm storage of produce.

Although not described in detail in the following pages, professional staff are also involved in cooperative research and development, technical assistance, and technical training on the international scene. During the past year, staff have participated in these kinds of activities in Brazil, Peru, and China, as well as in training activities within Canada for professional and technical staff from many countries. Fredericton staff also assisted in maintaining phytosanitary standards to ensure the export marketability of Canadian-grown potatoes.

The results reported herein provide an overview of continuing research programs. More complete information can be obtained from the Research Station, Research Branch, Agriculture Canada, P.O. Box 20280, Fredericton, N.B. E3B 4Z7; Tel. (506) 452-3260.

D.K. McBeath
Director

POTATO BREEDING

Potato breeding and variety development. Following the completion of full evaluation, two advanced selections from the Fredericton potato breeding program have been recommended for registration in Canada. F70021, recommended under the name Belmont, is a second early variety that produces round–oval, bright white-skinned, white-fleshed tubers with good table quality. It has high resistance to *Verticillium albo-atrum*, moderate resistance to potato virus Y, *Fusarium coeruleum*, and rhizoctonia, and slight to moderate resistance to potato leaf-roll virus. It has short tuber dormancy and potential in off-shore seed markets in the southern hemisphere. The second selection, F72090, is recommended for registration as Chaleur. It is also a second early variety and produces a high set of round–oval, slightly blocky, buff-skinned tubers with whiter than average flesh color and good table quality. Chaleur has resistance to potato virus Y, moderate resistance to common scab, and slight resistance to *Verticillium albo-atrum*.

Another advanced selection, F77087, tested in block trials in the Maritime Provinces, shows considerable promise as a chipping potato with moderate resistance to virus Y and common scab. This selection was also among the top entries in a trial of 15 Canadian and American varieties and advanced selections with potential for the chipping industry grown in Nova Scotia and New Brunswick.

In replicated maincrop yield trials conducted in 1987 at two locations in New Brunswick and one location each in Nova Scotia and Prince Edward Island, 13 Fredericton selections were evaluated and three were advanced for further testing. Seven Fredericton selections, considered to have potential in the seed export market, were evaluated for their ability to produce a good yield of small whole seed in trials in New Brunswick and Prince Edward Island. Twenty-seven entries, including 11 russet seedlings, were compared in a New Brunswick trial that is part of a cooperative United States project for the breeding and evaluation of new potato clones for the northeast (NE-107). This trial provides a valuable association with breeding programs in the eastern United States.

Shipping in vitro potato plantlets. To minimize the risk of loss when shipping valuable tissue cultures, guidelines were developed to assist laboratories in the preparation and packaging of cultures. About 3–4 weeks prior to shipment, cultures should be transferred to 15–20 mL of fresh, firmly solidified media in 25 × 150 mL test tubes. Parafilm should not be used to wrap cultures, since gaseous exchange would be inhibited, but filtering and sealing tapes may be used to wrap the closures on test tubes. Shipping boxes should be well packed with styrofoam chips to protect the contents from physical shock, and labeled "Fragile" in appropriate languages. Shipments must be timed to avoid weekends and holidays, arrangements for phytosanitary certificates and quarantine requirements completed in advance, and the recipient notified regarding the carrier and expected arrival time.

Irradiation for control of sprouting in potatoes. Several options exist for control of sprouting in potatoes – the use of cultivars with a long dormancy, storage of tubers at low temperatures (2–4°C), the use of chemical sprout inhibitors CIPC^{tm} and MH^{tm}, or the use of gamma irradiation.

In collaboration with Atomic Energy Commission Ltd. and the Ontario Potato Marketing Board, trials are being conducted to assess the effects of gamma irradiation on sprout control and tuber quality of a fresh market cultivar (Superior) and processing selections (Norchip, ND860-2).

Irradiation of tubers at 7–9 krad induced higher concentrations of sucrose, glucose, and fructose within 1 week after treatments, long-term storage of treated tubers produced excellent sprout control and no difference in the amount of bruising or breakdown of treated tubers compared to controls. Irradiation led to darkening of chip color in Norchip and selection ND860-2. Some improvement in chip color was noted several months after irradiation due to decreasing sugar content.

Large culture vessel developed for in vitro propagation. Petawawa germination boxes used by forest tree nurseries to test seed viability were adapted for use in plant tissue culture. These polycarbonate plastic boxes have interlocking and interchangeable tops and bottoms. The new culture vessel is autoclavable, and when used with sterile techniques does not introduce contamination problems. Sealing of the interlocking edges with either filtering or sealing tapes, which permit gaseous exchange, further reduces contamination. The culture vessel provides more head space for cultures than conventional vessels and its large size (approximately 28 × 24 cm) can accommodate up to 100 apple shoots or 60 potato single-node cuttings.

The genetic consequence of $2n$ gametes in 2×–2× crosses. The genetic consequence of $2n$ gametes produced by diploid parents in the progenies of diploid–diploid (2×–2×) crosses was studied, using theoretical models. Two alleles per locus (A and a) are considered and an additive-dominance genetical model is imposed on the five possible tetraploid genotypes (AAAA, AAAa, AAaa, Aaaa, and aaaa), while calculating means and variances of the progenies for the comparison of corresponding 2×–2×, 4×–2×, and 4×–4× crosses. There is no difference between crosses of various ploidy levels when the parents are homozygous (i.e., AA, aa, AAAA, and aaaa). The performance of 2×–2× crosses of the type AA*Aa and aa*Aa is identical to the corresponding 4×–2× ones AAAA*Aa and aaaa*Aa, respectively. The hybrids of Aa*Aa crosses, however, behave differently from AAaa*Aa and AAaa*AAaa crosses. Computer simulation results are obtained by assuming an additive or dominance (overdominance) model on the five tetraploid genotypes.

The first division restitution (FDR) gametes tend to give better mean performance in 2×-2× and 4×-2× hybrids than the corresponding 4×-4× ones under the dominance model when a gene is located close to the centromere, whereas the reverse is true for the second division restitution (SDR) gametes. The advantage of FDR gametes over SDR ones is gradually moved to the opposite direction when a gene is located toward the end of a chromosome. The effects of FDR and SDR gametes on variances of tetraploid progenies is opposite to those observed above. The 2*n* gametes appear to exert stronger influence on the variation of sizes of means and variances of tetraploid progenies of 2×-2× crosses than those of corresponding 4×-2× crosses. Progenies of SDR gametes show more drastic changes in means and variances than corresponding ones of FDR gametes when a locus of the concerned gene is moved from close to the centromere toward the end of a chromosome. The means and variances of tetraploid progenies of FDR*SDR crosses lie somewhere between those of corresponding FDR*FDR and SDR*SDR crosses. It is expected, however, that the means are higher and variances lower than those of corresponding 4×-4× hybrids for a gene located anywhere in the chromosome under the complete dominance model.

Evaluation of cultivars and breeding lines in collaborative trials. One feature of collaborative regional trials is that each of the participants agrees to conduct a trial with a common experimental design. The cultivars and breeding lines entered in the trials are based on recommendations of individual participants. For various practical reasons, not all entries are tested at all sites. This causes the resulting cultivar–breeding line × environment tables for such important traits as yield and specific gravity to be incomplete and, consequently, difficult to analyze to provide performance evaluations of the cultivars and breeding lines over all test environments. A statistical method that assumes a linear regression model of each of the cultivar–breeding lines in responding to the environments is used for investigating such data. Two parameters are measured to evaluate the merits of the cultivars and breeding lines: they are mean performance over all environments and sensitivity in responding to the environments. Analysis of yield data collected from NE-107 trials in 1985–1986 indicated wide variation of environmental effects. The cultivars and breeding lines showed differences in both mean performance and sensitivity to the environments. The results provide a means to evaluate the cultivars and breeding lines in terms of their adaptability to the environments.

POTATO PEST MANAGEMENT

Separation of viroid strains by electrophoresis. When nucleic acid extracts from leaves infected with various strains of potato spindle tuber viroid (PSTV) were electrophoresed by return-polyacrylamide gel electrophoresis (R-PAGE), viroid rubonucleic acid (RNA) migrated more slowly than other nucleic acids in the extract. Electrophoretic mobility of viroid bands from samples containing severe strain (S-PSTV) was 3–4 mm slower in the return direction than from samples containing mild strains (M-PSTV). Mixed preparations of severe and various mild strains separated into well-defined bands, which verified the differential migration of S-PSTV from M-PSTV strains. The origin of extracts from different organs of the potato (sprout, tuber, stolon, and leaf) or different plant species (tomato, potato, and *Scopolia sinensis*) did not affect the migration pattern of viroid strains. This method permits separation and identification of mild and severe strains of PSTV within a few hours, compared with several weeks required for the standard biological cross-protection test.

Detection of M-PSTV from the dormant tubers. Using a modified procedure of return-polyacrylamide gel electrophoresis (R-PAGE), mild strains of potato spindle tuber viroid (M-PSTV) were detected reliably from dormant tubers of 18 field-grown cultivars. The sensitivity of R-PAGE detection of M-PSTV was equivalent to that of nucleic acid hybridization. Both methods detected M-PSTV when infected tissue was mixed with healthy tissue in a ratio of 1:100. When extracted nucleic acid was diluted with buffer, R-PAGE detected PSTV at a dilution of 1:256, whereas nucleic acid hybridization detected only up to a dilution of 1:64. PSTV was readily detected from all 18 cultivars containing mild, intermediate, or severe strains of PSTV.

Detection of M-PSTV from single true potato seed. Mild strains of PSTV from single true potato seed (TPS) were detected by the modified R-PAGE. TPS lots obtained from field-grown PSTV-infected potato plants varied in their PSTV content. Viroid was detected in both dormant and germinated individual TPS. Dormant TPS contained approximately 0.8–10 ng of viroid RNA per seed. PSTV was detected by R-PAGE in nucleic acid extracts of single TPS, diluted to 1:16 (about 500 pg). Germinated seed and TPS seedlings grown in vitro at 19°C, showed similar rates of seed transmission. There was no change in PSTV detection in TPS seedlings grown for 4–10 weeks. In composite samples of infected and healthy TPS, PSTV was detected when one infected TPS was combined with 90–100 healthy seeds. Detection of PSTV by R-PAGE was comparable or superior to that obtained by nucleic acid hybridization.

Loss of PSTV from tubers after repeated freezing. Foliage and tubers infected with PSTV, when exposed to repeated freezing and thawing under controlled conditions, lost PSTV more rapidly from tubers than from foliage. In 7 of the 17 cultivars, PSTV was significantly reduced after one cycle of freezing and thawing, and in 6 of the 17 cultivars, infectious PSTV was still recoverable after exposure to four cycles. Exposure of PSTV-infected tubers to outdoor temperature fluctuations (13.1°C to −15.1°C) resulted in complete loss of PSTV from tubers. Hence, PSTV-infected tubers remaining in the soil may not serve as sources of contamination for a succeeding potato crop under Canadian winter conditions.

Glandular trichomes and whiteflies. A clone of the wild potato, *Solanum berthaultii* Hawkes, was found to trap the adult greenhouse whitefly *Trialeurodes vaporariorum* (Westwood), in the exudate from its glandular trichomes. In a comparative test with the commercial potato, *Solanum tuberosum* L. 'Red Pontiac', over a period of 48 days, the population of adults was 51% lower on the wild potato. No differences in oviposition preference, developmental period, or sex ratio could be found between populations reared on the two plants. This suggests that the resistance of *S. berthaultii* to whiteflies is mostly through physical entrapment.

The degree of resistance to whiteflies reported here is significant, but it is not sufficient by itself to provide whitefly control. Nevertheless, it opens new alternatives for Integrated Pest Management, especially in tropical countries where the whitefly can be a major potato pest outdoors.

Colorado potato beetle: Reproductive strategy. The guarding behavior of the female by the male after a first mating was studied by crossing white and black color morphs of the Colorado potato beetle, *Leptinotarsa decemlineata* (Say), used as genetic markers. Results from multiple matings showed that sperm mixing occurs in the spermatheca, providing only partial sperm precedence. Also, three copulations are required to fill the spermatheca; therefore, it is advantageous for the first male to remain with the female and guard her until a minimum of three copulations have been achieved.

The data support the competitive mate-searching theory where the male must decide between mating with an occupied female or with other females to maximize the progeny he produces. The male remaining with and guarding a female to prevent her from copulating again until her spermatheca has been filled with his sperm, maximizes his progeny and minimizes the number of eggs that future mates will be able to fertilize.

Tuber age as a contributory factor in the water relations of potato. During a slow-drying cycle of approximately 2 weeks duration, young expanding leaves on potato plants grown from young or old seed tubers of cultivar Alpha showed no evidence of osmotic adjustment, and prestressing the plants had no effect. Prestressed plants from young and old tubers possessed a higher relative water content at a zero turgor potential than unstressed plants. However, tuber age did not significantly affect the relative water content at zero water potential. Plants derived from young seed tubers exhibited improved drought resistance, such as reduced water loss from mature leaves, a larger root–shoot dry weight ratio, and possibly effects on root distribution in soil. Since drought stress is known to directly affect tuber development, any adverse factors affecting the ability of the plant to cope with drought stress (e.g., an unfavorable seed tuber age) would be expected to have an additional negative effect on tuber quality and yield.

Variation in carbohydrate esters from the glandular trichomes of certain Solanaceae species. Pest deterrent mucilages from the type

B glandular trichomes of certain wild potato species were found to be composed primarily of complex mixtures of sucrose esters. Sucrose substitution patterns varied substantially (i.e., from 3,4,6-tri-*O*- and 3,3',4,6-tetra-*O*-acylated in *Solanum berthaultii* to 2,3,3',4-tetra-*O*-acylated in *Solanum neocardenasii* accessions). The identity of the acyl substituents differed somewhat for each particular substitution pattern. For nine of 10 nontuberous *Solanum* species examined, 3,4-di-*O*- and 2,3,4-tri-*O*-acylated glucose esters constituted a major portion of the trichome exudate. Further diversity in the makeup of carbohydrate esters present in trichome exudate was found in other Solanaceae. For example, 2,3-di-*O*- and 1,2,3-tri-*O*-acylated glucose esters were identified in *Datura metel*, 2,3,6-tri-*O*-acylated sucrose esters in *Lycopersicon hirsutum* f. *glabratum*, and 2,3,4,6-tetra-*O*-acylated sucrose esters in *Petunia multiflora nana* trichome exudates.

Because of the possibility that variations in trichome carbohydrate esters have adaptive significance, these investigations should provide impetus for associated physiological and phytochemical studies. In addition, the knowledge already garnered provides some valuable monitoring tools for breeding programs aimed at developing related pest resistant varieties and for further establishing taxonomic relationships within the Solanaceae family.

Epidemics of potato leaf roll in North America and Europe linked to drought and sunspot cycles. Three major epidemics of potato leaf roll virus (PLRV) have occurred at approximately 32-year intervals in the northern seed-growing areas of eastern North America and western Europe during the 20th century, and they continue the cyclical pattern of earlier outbreaks of "the curl" in Europe, dating back to 1775–1784. Each epidemic lasted 5–10 years during a period of warm, dry climate that was favorable to the aphid vector, *Myzus persicae* (Sulzer), and served to extend its range northward. The epidemics could erupt sharply in a single season or intensify gradually over several, but typically there was a final flare-up, or climax, during an exceptionally warm summer. Termination was often abrupt, following one or more severe winters and a shift to cooler climate. The climax years, approximately 1784, 1812, 1846, 1878, 1912, 1944, and 1976, at least through the last four cycles, occurred when the minima of several concurrent rainfall cycles of 6–7, 11, and 16 years were nearly coincident, and near the minima of each third sunspot cycle. The epidemics coincided also with the onset phase of periodic droughts in the western Sahel of North Africa, one of the major climatic anomalies of the past century. PLRV is relatively common in the regions south of the major potato seed-growing areas, where warmer climate enhances the overwintering of *M. persicae*. If the northern hemisphere temperature continues to increase as it has in recent years, the fringes of such regions could shift northward and epidemics of PLRV in the seed-growing areas could be more frequent or prolonged.

ANIMAL AND CROPS

Effect of protein on forage intake. Feeding a protein supplement will frequently result in an increase in daily dry matter consumption by ruminant animals fed a low-protein forage or an ensiled forage containing a high proportion of nonprotein nitrogen. The reason for the response in intake is not well understood and does not occur with all forages.

No significant differences were found in voluntary intake by sheep of timothy silages made in Ag-Bag silos using techniques designed to induce good and poor fermentation patterns. The highest daily dry matter consumption (65.8 ± 1.22 g/kgW$^{-0.75}$) was for silage made from timothy grown with extra nitrogen fertilization and made in the normal manner. The lowest intake (58.4 ± 4.62 g/kgW$^{-0.75}$) was for timothy, with the control level of fertilization made using normal procedures. Silages made with the addition of a 10:1 barley–malt mixture added at 3% of the forage dry matter and silages made to encourage air infiltration were consumed at rates between these two extremes. The differences in intake were not significant ($P > 0.05$).

Dry matter digestibilities did not differ significantly among treatments and ranged from a low of 66.7 ± 1.8% for the control fertilization, normal ensiling procedure to a high of 69.6 ± 0.7% for the high-nitrogen fertilization, normal ensiling procedure.

The addition of white fish meal at 50 g/day did not have a significant effect on intake or dry matter digestibility of the silages but did increase protein digestibility of the diet from 67.8 ± 1.1% to 73.6 ± 0.8% ($P < 0.05$). The crude protein content of the high-nitrogen fertilized silage was not as high as expected (13.6% of dry matter) and compared with 11.2% for the control level of fertilization.

The differences in composition among these high-quality silages were not large enough to result in an effect on intake or digestibility by the sheep.

Sheep fed a mature timothy hay (5.8% crude protein) and 100 g/day of a barley-based supplement consumed 55.1 ± 6.2 $g/kgW^{-0.75}$ of dry matter. Replacing part of the barley with corn gluten meal, urea, or a mixture of the two did not result in a significant increase in dry matter intake or dry matter digestibility by the sheep. The dry matter digestibilities ranged from 56.5 ± 1.5% for the diet with the urea–corn gluten supplement to 58.1 ± 0.8% with the corn gluten supplement.

It was concluded that the mature timothy hay met the requirements of the mature wethers used in this trial. The protein supplements supplied did not result in the physiological response frequently seen when low-protein forages are offered to younger, growing animals. Decisions on the need to add a high level of by-pass protein source to the diet must be based both on the type of animal being fed and the characteristics of the forage being offered.

Using variation of near-infrared spectra to select forages for prediction equations. A statistical procedure that ranks the near-infrared reflectance (NIR) spectra of samples according to the magnitude of their variance from the mean spectrum of all samples (PICKS® algorithm, Technicon Instrument Corp.) provided a better selection of samples for deriving equations to predict some chemical constituents of forages than when selecting them randomly (R). The prediction sets consisted of 42 samples selected by either procedure from 229 forages that included nine timothy cultivars cut weekly from late in May to mid-August over 6 years. The chemical constituents related to nutritive quality analyzed were crude protein (CP), acid-detergent fiber, neutral-detergent fiber, lignin (L), in vitro true digestibility (TD), and in vitro cell wall digestibility (CWD). For the two calibration sets selected by either R or PICKS®, the multiple correlation coefficients of prediction equations using three wavelengths were similar for all constituents, ranging from 0.95 for L (PICKS®) to 0.98 for CP (R). However, the prediction equations derived from the samples selected by PICKS® had slightly larger estimated prediction errors that reflected the greater variance in the spectra of those samples. The prediction equations from samples selected by the PICKS® procedure gave lower standard errors of prediction for most constituents when applied to the remaining 187 samples, especially for TD and CWD. Using the PICKS® algorithm to select calibration samples gave prediction equations that accounted for more of the variation that occurred in the NIR spectra in the remaining samples. An additional advantage is that because the sample selection is based on spectral properties, chemical analyses need to be conducted on a minimum number of samples.

Effect of plant growth regulators on the composition and yield of alfalfa. Treatment of regrowth alfalfa with mefluidide or UC, a Union Carbide product, retarded development of the plants. After 22 days of regrowth, the leaf-to-stem ratios of plants treated with mefluidide and UC were 30 and 12% higher than controls. The contents of acid detergent fiber and cellulose were reduced, whereas the content of crude protein increased by applying the growth regulators. These differences in composition due to the treatments were reflected in higher rumen in vitro digestibilities of dry matter and plant cell wall. The yields of forage dry matter for 22 days growth were less from plants treated with either growth regulator, but this variance was partially compensated for by the retention of higher crude protein contents and digestibilities in the more juvenile plants.

Calf growth and rumen development when fed different forages. Forage consumption by calves during the first 2 months of life was not great. However, by the 4th month, those calves fed either grass silage (S) or a mixture of two parts grass silage to one part alfalfa hay (B) consumed those forages more readily than those fed timothy hay (T) ($P < 0.01$), whereas those fed alfalfa hay (A) were not different from any of the other groups. The mixed forage B was consistently consumed most readily in months 2, 3, and 4. There were no differences in starter consumption that was fed ad libitum to a maximum daily allotment of 2000 g.

There were no significant differences in weight gain during any of the 1-month time periods for this experiment. However, total gain for the S and B groups over the total 4 months of the test was greater than that of the T group ($P < 0.05$). The A group was intermediate to the other treatments and not different from any of them. Therefore, the S and B groups consumed more of their respective forages and responded with increased weight gains.

As the animals grew older, regardless of the forage fed, their rumen fluid acetate content increased and the propionate content decreased. Also, the pH of the rumen fluid was most acidic at 2 months of age and 0.3–0.4 unit greater at 3 and 4 months. All of these changes are probably related to forage becoming a greater percentage of the dry feed consumed by calves. The rate of in vitro methane production (μmoles per minute) from rumen fluid collected at the end of months 2, 3, and 4 and incubated with ground alfalfa hay was greatest for the T group. Methane production from the A and S groups was significantly less ($P < 0.05$) than from the T group. The B group was not different from any of the others.

Young calves can consume as much forage dry matter from silage as from hay. Timothy did not increase the rate of gas production from ground alfalfa, but the amount of methane produced was greater than from the other forages. Therefore, the type of forage fed to a young calf can have an influence on the development of the rumen population and the animal's growth in response to its diet.

ENGINEERING, HORTICULTURE, AND SOILS

Development of a remote temperature monitoring system for bulk vegetable storages. A prototype device was developed for monitoring temperatures in bulk vegetable storages. When the durable remote temperature transmitter is placed in a storage facility it senses the temperature and sends a signal to a receiver located outside the facility. The receiver then converts the signal into a temperature readout.

The system utilizes microprocessor technology for timing the actuation of data sensing and transmission, linearizing and digitizing the data, generating the identifier, and transmitting the data to the base station receiver. Two custom-designed microprocessor boards and a commercially available receiver and transmitter were incorporated in the design.

The temperature transmitter is a completely self-contained unit enclosed in protective plastic tubing to withstand harsh treatment. The transmitter has switch-selectable coding to uniquely identify its output to the receiver and to set its transmissions from once per hour to once per 24 h. To conserve power, a maximum transmission time of 1 s is used with the transmitter remaining in a sleep, or stand-by, mode for a large portion of the time. The receiver is capable of receiving the coded transmissions from 20 transmitters.

Lowbush blueberry plant response to variations in pruning for whole crop harvesting. Pruning lowbush blueberry plants in the dormant season at heights greater than 25 mm produced multiple lateral shoots emerging from nodes distributed the entire length of the remaining stem. During the next harvest season, the fruit clusters near the end of the shoots were too close to the ground to facilitate mechanical harvesting.

When the lowbush blueberry plants were cut during the fruit harvesting season, the plants that regrew during the next vegetative period were shorter and thinner, and established a less dense stand than plants that were fire-pruned in the dormant season. However, when this treatment was supplemented with a dormant season fire-pruning, then plant morphology and yield were similar to those pruned only in the dormant season.

It appears possible to introduce a whole crop harvesting system for lowbush blueberries without lowering crop potentials.

Rootstocks and training systems effect apple yields. Research with the McIntosh apple scion on six rootstocks in three different training systems during the first 13 years, including 8 years with crop, has shown that rootstocks were a significant factor in the yield of high-quality fruit. Yields were effected by the training system but varied over the fruiting years, resulting in no significant difference in accumulated production. Summerland strain McIntosh trees on rootstocks M.M. 106 and Beautiful Arcade, as well as Greenslade spur McIntosh on B.A., were larger and generally produced higher yields per tree than those on M26, Ottawa 3/B.A., and B.A./M26. At the tree spacing of 1.8 m × 4.0 m (1380 trees per hectare) the quality of the fruit on the smaller trees was higher, resulting in better grades.

The hedgerow training system was most productive in the first years of fruiting, but by the 4th year of production the spindlebush system gave the highest yields. By the 7th year of production the trellis system was producing the greatest yields and this continued during the final year of observation.

Control of blueberry maggot in New Brunswick. In 1987 one spray of dimethoate insecticide applied to lowbush blueberry sprout fields provided good control of blueberry maggot in adjacent fruiting fields, whereas in 1986 one or two sprays of dimethoate to sprout or crop fields provided effective seasonal control. This method of blueberry maggot control appears possible when used in conjuction with a monitoring program for the adult maggot fly, insecticides being applied only when trap catches indicate a need to control the flies. This method of control appears to be most effective when maggot populations are low or moderate.

Performance of strawberry cultivars. The strawberry cultivars Kent and Glooscap both produced high marketable yields and were rated among the top four cultivars during 5 years of testing.

When the strawberries were renovated and carried over for a second fruiting year, the Kent and Glooscap cultivars ranked among the top four cultivars in 3 out of 4 years. Other promising cultivars included Honeoye, K80-15, Blomidon, and Cornwallis.

In 1987, in a second crop trial, the cultivars Bounty, K80-15, Honeoye, Kent, and Glooscap all produced greater marketable yields than Redcoat, Micmac, and K81-12.

Leaching of applied phosphorus (P) into the subsoil of soils cropped to timothy. The concentration of Bray-1 P in the 0–15-cm depth layer of soils cropped to timothy for 26 years increased progressively with increasing rates of applied P. Even the lowest yearly rate of P application (47 kg/ha) significantly increased Bray-1 P concentrations in the 0–15-cm depth layer. The amount of applied P required annually to raise Bray-1 P concentrations by 1 mg/kg soil decreased from 64.2 kg/ha in the plots that received P at 47 kg/ha to 41.8 kg/ha in the plots that received P at 140 kg/ha. Usually the quantity of applied P required to raise soil test P concentrations by 1 mg/kg soil increases as the rate of P application increases. The trend that occurred here could be due to a greater proportion of the fertilizer P being taken up by timothy at the 47 kg/ha rate than at the 140 kg/ha rate.

There was considerable leaching of applied P into subsoil. Even at the lowest rate of applied P, Bray-1 P concentrations were significantly increased in the 15–30 and 30–45-cm depth increments. At the highest rate of applied P, Bray-1 P concentrations were significantly increased ($P = 0.05$) (40%) in the 45–60-cm depth increment. It should be remembered that all P was surface applied in this field trial.

These results clearly indicate that applied P was leached out of the zone of application into the subsoil of this mineral soil. In other work conducted on similar soils in New Brunswick, there was no leaching of applied P when potatoes were grown on the same plots for 26 years.

It is postulated that the discrepancy between the results of the two studies is due to changes imposed on the soil by the cropping practices. The soils were not plowed when timothy was grown. Undoubtedly, the chemical composition of the soil surface changed as it accumulated organic debris; hence, fertilizer P was applied to an organic rather than an inorganic layer. It could be that due to the highly acidic nature of the surface layer P was chelated by an aluminum–humic acid complex mobile in this soil.

Ground-penetrating radar (GPR). Drainage tiles installed between 1 and 50 years ago in fluvial, till, and marine deposits were located by GPR with 100% accuracy. A method to eliminate interference signatures caused by buried stones or by bore holes of mammals was developed, using graphic outputs of two nearby traverses. Ground-penetrating radar also shows promise for determination of the depth of tile drains below the surface of the ground.

Subsurface drainage and land use in New Brunswick. A general description of New Brunswick subsurface drainage activity and associated agricultural effects was generated based on historical records and a farmer survey that encompassed 83 farmers and 50% of the subsurface drainage installed (1600 km) during the period 1978–1984. The survey results are not specific to soil type and can not be used to identify or solve specific soil–water problems. However, the character of the interrelationships among subsurface drainage, land use, and agricultural productivity is illustrated, and farmer opinions on various aspects of subsurface drainage are revealed. These factors should be considered when formulating future land-related research or extension programs.

The following observations were drawn from the data collected:

- The availability of private drainage contractor services, together with appropriate government-sponsored cost-sharing programs, increases the quantities of subsurface drainage installed.
- Dairy producers are currently the largest user group of subsurface drainage in New Brunswick, accounting for approximately 50% of the total subdrain installation over the period 1978–1986.
- Most subsurface drainage in New Brunswick is being employed to rectify obvious wet conditions rather than to fine tune already aggressive crop management systems. Only 10% of those surveyed reported that their land was cropped regularly prior to drainage improvement.
- Most producers feel that subsurface drainage is having a positive effect on their farming operations. Ninety-nine percent indicated that production efficiency on their farm was either greatly improved (59%) or improved (40%) because of the investment in subsurface drainage.
- Future drain spacings should be similar to or narrower than those already installed. (This assumes no use of secondary drainage treatments.)
- A large portion of the farmers interviewed are producing alfalfa on at least some of their subdrained land.
- There is more land requiring drainage improvement in New Brunswick. Only 4% of those interviewed felt that drainage improvements on their farms were now completed.

V-notch weir boxes for measurement of subsurface drainage system discharges. Case studies or field experiments that assess the performance of subsurface drainage systems often require the accurate determination of drainage system outflow on a periodic or continuous basis. Maximum flows of 10–20 L/s may be encountered at a single outlet, depending on drain depth and spacing, soil-saturated hydraulic conductivity, the number and length of drain laterals in the system, and the capacity of the collector or main line. Accurate measurement of these flows requires a discharge measurement structure that operates over a range of heads easily detectable with common stage-recording devices such as float-pulley systems, bubblers, or pressure transducers.

Construction drawings and calibration results were developed for two non-90° sharp crested V-notch weir boxes designed to discharge a maximum of 10 and 20 L/s at 300 mm of head. The completed structures were lightweight, durable, compact, simple to construct, and baffled to reduce turbulence in the approach section to the notch. Standard 10 × 20 cm (4 × 8 in.) sheets of 3-mm aluminum were the primary building materials.

Nuclear and core methods for the measurement of soil bulk density and moisture content. Field comparisons using clay loam, sandy loam, and silt loam soils between a single-probe nuclear method and a core-sampling method for wet and dry soil bulk density and for moisture content indicated the need for careful calibration of the nuclear unit. Significant differences between methods appeared in the measurement of volumetric moisture content in the sandy loam and silt loam at depths of 280 and 530 mm. This suggests that the probe should not be used to measure soil moisture at depths greater than 150 mm. Significant differences between the probe and core methods were found in the wet bulk density and dry bulk density measurements in the clay loam and sandy loam. The results in the silt loam were not revealing about density measurement due to a uniform density with depth in that soil.

Subsoiling and speed in compact soils. The speed of subsoiler tool movement through pedogenetically compacted clay loam and sandy loam soils had a highly significant linear effect on the measured vertical force. Speed had a highly significant quadratic effect on the horizontal force, total force, moment, and specific resistance. In all instances, however, the contribution of speed or speed squared was small, indicating little variation in the force with tool speed. Soil type also had a highly significant effect on the forces, the moment, and the specific resistance resulting in higher draft forces in the clay loam soil. No interactions between soil and speed or between soil and speed squared were observed, indicating a similar response in both soil types, even though these soils have vastly different mechanical properties and strengths. Neither soil type nor speed had significant effects on the soil areas

heaved or disturbed, total area, width of disturbance, or swell factor.

Soil disturbance in compact soils. An experiment to compare the soil disturbance produced by a deep-operating subsoiler share with or without wings confirmed the existence of a critical depth below which little soil loosening occurs in both a compact clay loam and a compact sandy loam. A difference in the critical depths in the two soils was observed. The results also show that the 26-cm wide wings had no advantage over the 7.5-cm share in terms of area of soil disturbed when operating above the critical depth. The wings did, however, significantly increase the critical depth in both soils. The wings also significantly improved the reduction in the dry bulk density of the clay soil. The results demonstrated the value of wings on simple tillage tools operating in compact soils.

FERME EXPÉRIMENTALE SÉNATEUR HERVÉ J. MICHAUD BOUCTOUCHE, N.-B.

Carotte. Une étude faite sur sol organique en 1987 a démontré que l'apport de molybdène augmentait considérablement le rendement de la carotte. Le traitement molybdène plus chaux et le traitement molybdène sans chaux ont donné les meilleurs rendements en carottes vendables (22,8 t/ha et 20,0 t/ha). Les traitements avec cuivre et avec bore, incluant l'addition de chaux, ont produit significativement plus (10,4 t/ha, 9,1 t/ha) que le traitement témoin (4,6 t/ha) mais non significativement plus que le traitement témoin plus chaux (7,5 kg/ha).

Choux. Douze cultivars de choux récoltés en novembre 1986 ont été mis en entrepôt réfrigéré pour une période de 4 mois. Le Jupiter a eu le plus haut pourcentage de choux vendables avec de très bonnes caractéristiques de qualité telles que la couleur extérieure et intérieure. Les cultivars Lennox, Bartolo, Bislet, Polinius et Slawdena se sont également très bien entreposés.

Navet fourrager. Quatre cultivars de navets fourragers ont été identifiés supérieurs dans un essai qui s'est échelonné sur 3 années à Bouctouche. Le Buro et le Appin sont des cultivars feuillus et résistants aux maladies tandis que le Barkant et le Marco sont des cultivars à proportions égales de racines et de feuilles. Ces cultivars ont réalisé des rendements moyens en matière sèche de 10 200 kg/ha en 1987, 8950 kg/ha en 1986 et 15 500 kg/ha en 1985. La moyenne des 3 années est de 11 550 kg/ha de matière sèche.

Régie intensive de l'orge. Au cours d'un essai de 2 ans à Bouctouche, nous avons effectué cinq niveaux de régie sur le cultivar Léger. Les traitements portaient sur l'application supplémentaire d'azote, des traitements de fongicide (Tilt) et des traitements de régulateurs de croissance (Cerone) au stade de croissance approprié pour chaque traitement. Des rendements de 4,7 et 4,8 t/ha ont été réalisés en 1986 et de 4,2 à 5,1 t/ha en 1987.

Framboisiers. En 1981, 1983 et 1984, nous avons établi des parcelles d'essais pour l'évaluation de cultivars de framboisiers. Les trois plantations sont des haies fruitières de 60 cm de largeur. Le cultivar Festival est commun aux trois essais qui comptent respectivement chacun 4, 4, et 7 cultivars et lignées. Le cultivar standard Festival a obtenu un niveau de productivité comparable dans les trois essais à la troisième fructification, soit 7314, 7454, 7693 kg/ha. Dans l'essai 1981, le Festival a une production égale ou supérieure au Boyne et au Carnival depuis 6 ans. Dans l'essai 1983, le Festival a eu une production inférieure au Nova mais supérieure au Matsqui et au K65-12 pendant les premières saisons de fructification, mais a dépassé le Nova en 1987. Enfin, dans l'essai 1984, les cultivars Newburg, Titan et K74-1 ont un rendement égal ou supérieur à celui du Festival après 2 années de production. Les cultivars Nova, Titan et K74-1 ont chacun un niveau de productivité qui pourrait permettre de les utiliser en remplacement du cultivar Festival, là où la rouille jaune tardive l'affecte particulièrement. Le cultivar Nova en particulier semble offrir une immunité à cette maladie. Cependant, cette maladie n'a pas été importante en 1987 en raison d'un climat non favorable à son développement.

Groseilles. Vingt-trois cultivars et lignées de groseilles ont été plantés au cours des saisons 1984 et 1985. Des fruits ont pu être récoltés sur tous les cultivars dès 1986. Les deux cultivars les plus productifs en 1986 et 1987 sont le Hinnonmake (jaune) avec 5,3 et 7,4 kg par buisson et le Pixwell (rouge) avec 5,8 et 8,0 kg par buisson. En plus du niveau de

productivité, tous les buissons sont évalués pour leur résistance aux maladies et aux conditions climatiques.

Sureaux. Huit cultivars de sureaux ont été établis dans une parcelle d'essai réplique. Les cultivars Adams, Johns, Maxima, Nova et York ont été plantés en 1984 et le Kent, le New York et le Victoria en 1985. Une première récolte a été prélevée en 1986 et une seconde en 1987. La période de production de tous les cultivars semble convenir au climat de cette région, sauf pour le Maxima, dont la période de maturité semble trop tardive. La survie à long terme et la productivité réelle en fruits de qualité restent cependant à évaluer sous les conditions du sud-est du Nouveau-Brunswick.

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C. Passey, B.E.(Hons.), M.E., M.B.A., D.Sc.	Chef de section; génie alimentaire

Arômes et extraction

J.R.J. Paré, B.Sc., Ph.D., C.Chem., M.R.S.C.	Chef de section; spectrométrie de masse
J. Bélanger, B.Sc., B.Ed., M.Sc., Ph.D.	Extraction

Départs

S. Gauthier, B.Sc., M.Sc., Ph.D.	Protéines
J. Rolland, B.Sc.A., M.Sc., Ph.D.	Ingrédients laitiers

CHERCHEURS INVITÉS

P. Chevalier, B.Sc., M.Sc., Ph.D.	Bioréacteur
M. Dardiri,[10] B.Sc., M.Sc., Ph.D.	Irradiation
B. Kalman,[10] Chem. Eng., Ph.D.	Irradiation
J.H. Kwon,[10] B.Sc., M.Sc., Ph.D.	Irradiation
N.D. Patil, B.Tech., M.Tech., Ph.D.	Extraction supercritique – blanchiment
N. Ramarathnam, B.Sc., M.Sc., Ph.D.	Produits naturels

Étudiants à la maîtrise

M.I. Barriga responsable, C. Willemot	Atmosphère contrôlée – tomate
C. Brossard responsable, F. Cormier	Culture de cellules végétales
N. Daly responsable, C. Willemot	Potentiel d'entreposage
J. D'Amour responsable, C. Willemot	Irradiation des fraises
M.L. Desjardins responsable, D. Roy	Produits laitiers fermentés
S. Jacquemin responsable, A. Morin	Enzymologie
A. Lopez-Dominguez responsable, C. Willemot	Irradiation – brocoli
R. Laing responsable, J.R.J. Paré	Hydrates de carbone
Y. Raymond responsable, A. Morin	Enzymologie

Étudiants au doctorat

M. Akier Assanta responsable, D. Roy	Listeria
G. Arora responsable, B. Lee	Enzymologie

J. Berger responsable, B. Lee	Enzymologie
F. Chéour responsable, C. Willemot	Conservation des fraises
R. Couture responsable, C. Willemot	Irradiation des fraises
G. Doyon responsable, C. Willemot	Atmosphère modifiée
J. Fichtali responsable, C. Toupin	Extrusion
M. Lamontaghe responsable, B. Lee	Génétique lactique
J. Makhlouf responsable, C. Willemot	Atmosphère contrôlée – brocoli
K.S. Pannu responsable, C. Passey	Stérilisation
L. Romo responsable, C. Willemot	Atmosphère contrôlée
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INTRODUCTION

Le Centre de recherches alimentaires de Saint-Hyacinthe est le plus récent des établissements de recherches d'Agriculture Canada. Il est situé au coeur de la deuxième concentration d'industries alimentaires au Canada. Inauguré officiellement le 5 juin 1987 par l'honorable John Wise, le Centre a connu une première année intense de mise en opération et de rodage. Par la création de ce centre, le gouvernement veut contribuer au développement économique de l'industrie agro-alimentaire de la région et du Canada.

Son programme comporte trois volets majeurs : l'aide à l'industrie, la recherche en collaboration et la recherche thématique. Dans son volet d'aide à l'industrie, le Centre met à la disposition du secteur industriel ses installations, ses services et ses experts pour lui permettre d'effectuer sa propre recherche-développement d'une manière très confidentielle. Des services de recherches bibliographiques, d'analyse sensorielle, de formation en opération d'équipements et d'instruments et de traitement des données sont également offerts à l'industrie. La recherche en collaboration opère sur le principe du partenariat où le Centre met des ressources en commun avec un autre intervenant pour accélérer le développement de nouvelles technologies. Les chercheurs fédéraux du Centre poursuivent un programme de recherches thématiques sur des thèmes plus génériques destinés à préparer les technologies de demain. L'accent est mis sur les industries du lait, de la viande et volaille, de la boulangerie, des fruits et légumes, d'additifs alimentaires et de génie alimentaire (nouveaux procédés et prototypes d'équipement). Le Centre de Saint-Hyacinthe compte jouer un rôle de leadership à l'intérieur du Ministère dans les domaines suivants : lait, biotechnologie appliquée à l'alimentation, technologies d'extraction, technologies d'emballage et de conservation et application de l'irradiation en industrie alimentaire.

Au cours de la première année d'opération du Centre, la réponse de l'industrie a dépassé les prévisions. Quelque 69 projets industriels ont été enregistrés dont 21 ont été achevés, 16 sont en voie d'exécution et 40 sont en attente, fin décembre 1987. Il est à prévoir que le Centre ne pourra plus bientôt accueillir d'autres clients du secteur industriel tellement la demande est grande. Les retombées ne tarderont pas à se faire sentir, étant donné que cinq nouvelles compagnies alimentaires ont déjà acquis des lots dans le voisinage du Centre et qu'on est en train de planifier la construction d'un condominium.

Des groupes de recherches multidisciplinaires et interinstitutionnels ont été formés avec dix organismes externes (industries, universités, instituts). Trois universités ont octroyé à six de nos chercheurs le statut de professeur auxiliaire. Le transfert technologique a été une de nos principales activités en 1987 puisque les membres du personnel du Centre ont participé à 67 entrevues, 22 conférences, 77 publications, 68 communications et 3 déclarations d'invention. De plus, le Centre a accueilli 10 300 visiteurs et des délégations en provenance de 15 pays étrangers. Il a aussi participé au prestigieux Sommet de la francophonie en prenant part à l'organisation et au programme de la Conférence sur la conservation des aliments.

On peut obtenir des renseignements additionnels sur les activités du Centre en s'adressant au Centre de recherches alimentaires, 3600, boul. Casavant ouest, Saint-Hyacinthe, Québec, J2S 8E3; Tél. (514) 773-1105; FAX (514) 773-8461.

René R. Riel
Directeur

ATMOSPHÈRE CONTRÔLÉE

(En collaboration avec l'Université Laval)

Conservation du brocoli et du chou-fleur sous atmosphère contrôlée. On a observé qu'une atmosphère contrôlée contenant 2,5 % d'O_2 et 8,5 % de CO_2 retarde la maturation du brocoli, si on tient compte des critères suivants : couleur, perte de chlorophylle, apparition de pourriture et de moisissure, et mauvaises odeurs. La conservation du brocoli a été prolongée jusqu'à 7 semaines à 1 °C. De plus, le cultivar Green Valiant s'est révélé plus résistant aux maladies et sa conservation a été supérieure aux autres cultivars du commerce.

Une atmosphère de 3 % d'O_2 a prolongé la conservation du choufleur à 1 °C. Le traitement a réduit le taux respiratoire, ralenti le jaunissement et retardé l'apparition de points noirs et de micro-organismes. Une concentration de 2,5 à 5 % de CO_2 a eu un effet bénéfique additionnel et a permis une conservation allant jusqu'à 7 semaines.

Toutefois, la conservation à 10 % de CO_2 ou bien un prétraitement dans une atmosphère à 15 % de CO_2 ont au contraire accéléré la dégradation du chou-fleur et causé le ramollissement des tissus.

Effet de l'éthylène sur la sénescence du brocoli. On a trouvé que l'éthylène exogène accélère la sénescence du brocoli causée par une augmentation de la respiration et une perte de chlorophylle plus rapide, ceci même au niveau de 1 ppm d'éthylène. L'éthylène exogène semble donc stimuler la biosynthèse de l'éthylène au niveau du EFE («ethylene-forming enzyme»).

Entreposage des tomates sous atmosphère contrôlée. Des résultats expérimentaux ont démontré qu'une atmosphère de 3 % d'O_2 et de 5 % de CO_2 retarde le mûrissement des tomates vertes à 20 °C. La respiration et la production d'éthylène diminuent, tandis que le climatérique se présente plus tard et est moins prononcé.

FROMAGES

Rendements fromagers. Dans des travaux faits en collaboration avec l'Université Laval, il a été possible d'améliorer les rendements fromagers en enrichissant du lait frais avec des solides de lait ultrafiltré. On a obtenu des augmentations de rendement allant jusqu'à 13 % et sans modifier le mode usuel de fabrication du fromage (temps de cuisson, temps de soutirage, etc). Le changement a porté seulement sur le phénomène de la coagulation. Pour évaluer ce phénomène, nous avons mis au point une méthode de mesure objective (Instron) qui nous a permis de constater que la coagulation était plus rapide lorsque le lait était enrichi en protéines, et cela en corrélation directe avec le taux d'enrichissement.

ASPERGES

Classification. Dans le but d'uniformiser le contrôle de la qualité des légumes lors de la cueillette aux champs, nous avons développé un outil visuel permettant une classification homogène des caractéristiques physiques des asperges. Il s'agit d'une série de sept tableaux qui permettent de visualiser un nombre de facteurs ou de critères de qualité comme la longueur, le diamètre et le degré de courbure des asperges fraîches ou transformées. Ces tableaux peuvent également servir à la classification du céleri, des carottes ou tout autre produit végétal qui est relativement droit ou avec un angle de courbure maximal de 24°.

Ces feuilles d'examen peuvent également servir à la formation uniforme et rapide du personnel d'une entreprise, soit aux champs soit à l'usine. De plus, ces tableaux peuvent aider les généticiens et les agronomes dans leurs travaux de sélection des légumes et d'identification des critères de qualité, avec des tolérances respectives. Même le commerçant, le grossiste ou l'acheteur peuvent les apprécier pour mieux se familiariser avec les normes gouvernementales ou encore lors de la préparation des contrats d'achat.

Ces feuilles d'examen visuel sont présentées dans les deux langues officielles selon les systèmes métrique et impérial. Pour une utilisation courante, elles devraient être plastifiées et scellées entre deux feuilles d'acrylique ou de plexi assurant ainsi une protection additionnelle.

PHYSIOLOGIE VÉGÉTALE

Méthode de caractérisation. Dans le but d'étudier et d'analyser le comportement biochimique des tissus végétaux, on a créé et mis à l'épreuve une méthode par chromatographie liquide à haute performance (C.L.H.P.). Notre but était d'obtenir une bonne séparation des acides organiques carboxyliques, sucres simples et alcools.

On a utilisé une colonne à interaction ionique avec phase mobile 0.005 N (H_2SO_4), à une température de 25 °C, couplée à deux détecteurs en séries (U.V. et I.R.) pour la détection et la quantification. Les essais de mise au point ont permis d'identifier et de séparer près de soixante (60) composés d'intérêt en physiologie végétale (respiration), physiologie microbienne et maturation de produits laitiers.

On a présenté sous la forme pratique de tableau les facteurs ou paramètres chromatographiques suivants : le temps de rétention (t_r), le facteur de capacité (K'), le facteur de sélectivité (α) et le minimum détectable (D).

Caractérisation biochimique des fraises. On a appliqué la chromatographie liquide à haute performance (C.L.H.P.) à la caractérisation des acides organiques carboxyliques, sucres simples et alcools pour diverses variétés de fraises. Des mesures avec celles de l'humidité et du pH sont proposées comme base de caractérisation des fraises.

L'étude a porté sur cinq (5) cultivars : trois du type conventionnel (Kent, Redcoat et Veestar) et deux autres moins courants (Tribute et Tristar).

Pour l'ensemble de ces cultivars, l'humidité a varié de 88,6 à 90,7 % et le pH de 3,2 à 3,4. La teneur des sucres et des acides carboxyliques totaux mesurées ont varié de 4,2 à 7,0 % et 0,81 à 1,06 % respectivement.

L'acide citrique vient en tête des acides organiques avec des valeurs extrêmes de 0,52 pour le Kent et 0,67 pour le Redcoat. L'acide malique vient ensuite avec 0,21 % pour le Veestar et 0,47 % pour le Tribute. Le rapport citrique : malique a été de 1,2 à 1,7 pour le Tribute, le Kent et le Tristar; par contre, ce rapport a été nettement plus élevé chez les cultivars Redcoat (2,2) et Veestar (3,0). Le rapport glucose : fructose a été de 0,75 et 0,78 respectivement pour le Redcoat et le Tribute, par contre, le Kent, le Tristar et le Veestar ont eu des rapports de l'ordre de 0,81 à 0,84. Les autres acides quantifiés ont été l'acide succinique (0,01–0,04 %) et l'acide phospho-enol-pyruvique (0,001–0,009 %). La quantité de méthanol déterminée dans ces cultivars de fraise a été de l'ordre de 0,10 %.

Il est proposé que le rapport critique : malique soit considéré à l'avenir comme paramètre d'activité métabolique et d'activité respiratoire, pour la sélection des cultivars de fraises destinés à l'entreposage.

Ralentissement du mûrissement des fraises après récolte par traitement prérécolté au calcium. Un traitement au $CaCl_2$ (10–20 kg/ha) a retardé le mûrissement des fraises (sucres libres, acidité titrable, anthocyanes, fermeté, moisissures) au cours de l'entreposage à 4 °C. La teneur en calcium a augmenté dans les feuilles et les fruits en étroite corrélation. Le traitement a eu plus d'effet dans une fraisière dont le sol contenait peu de calcium que dans une autre dont le sol était plus riche en cet élément.

IRRADIATION

Effets des rayons gamma sur la conservation des fraises et du brocoli (En collaboration avec l'Université Laval). L'irradiation à une dose de 2 kGy retarde de façon très marquée l'apparition de la moisissure grise (*Botrysis cinerea*) au cours de l'entreposage des fraises à 4 °C. Le mûrissement des fraises implique certains changements au niveau des lipides membranaires : la proportion des lipides polaires augmente, ainsi que le pourcentage des acides stéarique et oléique. Le pourcentage des acides palmitique et linoléique diminue. L'irradiation n'a pas semblé affecter ces lipides.

Des résultats préliminaires indiquent qu'au cours de l'entreposage des fraises la combinaison d'une atmosphère contrôlée (5 % d'O_2, 10 % de CO_2) pour inhiber les moisissures, et d'une très faible dose d'irradiation (0,3 kGy) pour retarder le taux de mûrissement, pourrait être préférable à une dose d'irradiation de 2 kGy. Celle-ci peut fort bien contrôler les micro-organismes et le taux de mûrissement, mais c'est au détriment de l'intégrité des tissus. En effet, on a démontré que l'irradiation peut affecter légèrement les parois cellulaires avec libération de pectines solubles.

Le brocoli est très sensible aux rayons gamma, même à une dose de 1 kGy. Cette dose est celle requise généralement pour contrôler les micro-organismes au cours de l'entreposage. On a observé que l'irradiation stimule la respiration et accélère le jaunissement et la perte de chlorophylle, particulièrement dans les tiges, ainsi que la dégradation de l'apparence générale.

Aliments pour animaux. À la demande de l'industrie et en collaboration avec elle, le Centre poursuit des travaux sur l'irradiation d'aliments destinés au vison. Aucune observation négative n'a été rapportée jusqu'ici sur les paramètres de santé, croissance, reproduction et qualité de la fourrure chez le vison nourri aux aliments irradiés.

BIOTECHNOLOGIE

Production de Leuconostoc oenos sur le jus de pomme. La production de *Leuconostoc oenos* sur le jus de pomme est faite dans le but d'obtenir des biomasses qui seront lyophilisées et ajoutées aux moûts afin d'induire ou de hâter la fermentation malolactique des vins. On a étudié plusieurs paramètres de production. On a obtenu les meilleurs rendements avec les conditions générales suivantes : 2,5–5 % de solides de pomme, 0,5–1 % d'extraits de levure et de peptone (soja), 25–30 °C. Compte tenu des grandes variations qui ont été observées entre les souches, il devient nécessaire d'établir les conditions optimales de croissance de chacune d'elles pour en adapter la production en conséquence.

Psychrotrophes dans le lait. La croissance de psychrotrophes dans le lait est à l'origine de défauts importants dans les produits laitiers. Nous avons étudié l'effet de l'inoculation de bactéries lactiques au lait crû réfrigéré sur la croissance des psychrotrophes. L'addition de ferments produits sur le lait n'a pas donné de bons résultats, la croissance des psychrotrophes étant parfois stimulée. Par contre, l'addition de suspensions concentrées a été plus efficace. Il est donc recommandé à l'industrie de ne pas utiliser ses propres ferments lactiques comme inoculants mais d'avoir plutôt recours aux ferments concentrés des fournisseurs spécialisés. On a observé une forte corrélation (0,90) entre la production d'acides butyrique et caproïque et la croissance des psychrotrophes dans le lait.

Génie génétique. Nos travaux en génie génétique ont permis d'exprimer avec succès le clone de la lactase de *S. thermophilus* afin de le transférer dans un organisme hôte *S. cerevisiae*.

Bioprocédés. Des travaux menés en collaboration avec l'industrie privée ont porté sur la concentration d'un champignon filamenteux, produit en culture submergée, par microfiltration tangentielle sous conditions aseptiques, tout en voulant maintenir sa viabilité et son infectivité. Nous avons comparé deux configurations de systèmes de microfiltration stérilisables à la vapeur (tubulaire et plane). Nos résultats démontrent que la composition du milieu de culture a un effet sur les performances de filtration. Pour des taux de cisaillement inférieurs ou comparables, la configuration tubulaire permet d'obtenir des débits de filtration moyens plus élevés. Considérant le fait que les propagules se brisent et améliorent ainsi dans une certaine mesure la viabilité et l'infectivité, nos résultats ont démontré que pour une durée de traitement inférieure à 1 h, il n'y a pas de perte d'infectivité significative. Les essais de fermentation et de concentration à l'échelle pilote ont confirmé les résultats obtenus à l'échelle du laboratoire.

Bioréacteur. On a mis au point un bioréacteur pour la production de précurseurs d'acides aminés en faisant appel à une souche de *Pseudomonas* produisant une D-hydantoinase. La production de ces précurseurs par des bactéries libres est facilement réalisable mais la biomasse bactérienne peut gêner la récupération de *n*-carbamyl. Grâce à notre compétence dans le domaine de l'immobilisation cellulaire, nous avons choisi cette approche. L'immobilisation du pseudomonas avec utilisation d'alginate a démontré que des cellules immobilisées peuvent produire autant d'hydantoinase que des cellules libres. Ceci peut se faire avec des bactéries immobilisées en lit fixe ainsi qu'en utilisant un réacteur membranaire de type fibres creuses.

Bifidobactéries. On a obtenu des résultats intéressants dans une étude en collaboration avec l'Université Laval, sur la cinétique de croissance des bifidobactéries. Nous avons étudié 21 souches du point de vue de leur performance de croissance, de leur pouvoir acidifiant et de leur production d'acides dans le lait. Selon ces critères, les bifidobactéries ont pu être classées comme rapides ou lentes en termes d'activité. Le rapport acide lactique : acide acétique produit au cours de la fermentation a varié de 1:3 à 1:5, s'écartant appréciablement du rapport théorique de 2:3. Il nous a été possible d'obtenir jusqu'à 10 milliards de cellules viables par millilitre au cours de la fermentation d'un lait écremé sous contrôle de pH. Cette technologie ouvre la voie à de multiples applications intéressantes dans l'industrie.

Culture de tissus. Parmi les principaux problèmes rencontrés lors de la bioconversion des monoterpènes par des suspensions de cellules végétales, il y a la toxicité de certains substrats ou produits à faible concentration, l'état transitoire des produits naissants et le temps requis pour obtenir la suspension cellulaire. Pour contourner ces difficultés, on a mis au point une technique de bioconversion extractive qui fait appel à un système biphasique consistant en une phase nutritive aqueuse surmontée d'une phase lipidique. Ce système a permis d'augmenter de cinq fois la capacité des cellules végétales à convertir des monoterpènes et il permet de recycler ou réutiliser les cellules végétales dans le procédé de bioconversion.

Polysaccharides. Certains polysaccharides microbiens sont d'intérêt alimentaire à cause de leurs propriétés épaississantes, gélifiantes ou émulsifiantes. De plus, certains d'entre eux représentent une source intéressante de monosaccharides qui sont recherchés pour la synthèse de composés aromatiques. À cette fin, on a sélectionné des lignées microbiennes pour leur capacité à produire des polysaccharides contenant du rhamnose. Nous avons mis au point une technologie de production qui a permis d'augmenter le rendement par un facteur de 25. On a mis au point également une procédure de séparation des polysaccharides suivie de leur conversion en monosaccharides et la séparation de ces derniers.

LES VIANDES

Les nouvelles méthodes chromatographiques qui ont été créées dans les laboratoires de biochimie musculaire du Ministère au Collège Macdonald permettent de quantifier 50 acides aminés dont les acides aminés uniques τ-methylhistidine, 4-hydroxyproline, 5-hydroxylysine et desmosine présents dans certaines protéines musculaires.

Nous avons appliqué avec succès ces méthodes à la détermination quantitative des tissus myofribrillaires et conjonctifs dans une série d'échantillons de muscles et de tissus. Ces tissus sont précisément à la base de l'évaluation de la qualité protéique des produits de viande et de volaille. Les travaux ont démontré que les additifs et ingrédients protéiques non carnés qui pourraient communément être utilisés pour allonger les viandes ne contiennent pas de α-méthylhistidine, de 5-hydroxylysine ni de desmosine. Voilà pourquoi la quantification de ces trois acides aminés uniques dans des hydrolysats de viande peuvent nous permettre d'évaluer la qualité des protéines des produits carnés.

GÉNIE DES PROCÉDÉS

Blancheur. On a mis au point un nouveau procédé de blanchiment, le HTST. Celui-ci permet d'une part d'éliminer les pertes par entraînement et d'autre part d'améliorer les qualités organoleptiques, nutritionnelles et bactériologiques des légumes. Nous avons réalisé l'ingénierie des principales composantes de cet appareil.

Supercritique. Nous avons pu extraire l'huile d'un lot d'arachides sans que ces dernières ne soient brisées. Des travaux sont présentement en cours afin de définir les paramètres de l'extraction supercritique dans le but d'obtenir un produit à faible teneur en calories.

Cristalliseur. Avec l'aide de notre ingénierie, l'Université Laval a mis au point un prototype de colonne à fractionnement par cristallisation de la matière grasse laitière.

Stérilisateur. On a mis au point, au Centre, un nouveau procédé pour la stérilisation de produits alimentaires comme les pois, les cubes de carottes et les pommes de terre afin de créer un stérilisateur prototype. L'Université Laval a construit un simulateur afin d'étudier les propriétés thermophysiques et hydrodynamiques des produits mentionnés plus haut ce qui a permis de mieux définir les paramètres nécessaires à la conception de l'équipement et du procédé.

Le trait particulier de ce nouveau procédé est la stérilisation des aliments sans qu'ils soient submergés dans un liquide. Étant donné qu'ils sont stérilisés par de la vapeur surchauffée, les aliments ainsi traités conservent leurs qualités nutritionnelles et organoleptiques très proches de celles du produit frais. De plus, cette technologie permettra de faire d'importantes économies d'emballage et de distribution, et de réduire l'espace d'entreposage.

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Station de recherches Lennoxville, Québec

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J. de Léséleuc	Services administratifs

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S. Gagné-Giguère,[1] B.A., M.A., M.Bibl.	Bibliothèque
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S.A. Pommier, B.Sc., M.Sc., Ph.D.	Qualité des viandes – bovins, porcs
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C. Fernet, B.Sc.	Amélioration des plantes
P.M. Flipot, B.Sc.(Agr.), M.Sc., Ph.D.	Nutrition – bovins de boucherie
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H.V. Petit,[6] B.Sc.(Agr.), M.Sc., Ph.D.	Physiologie de la digestion – bovins
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Départs

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Étudiants à la maîtrise

S. Beauregard responsable, P. Savoie	Génie rural
P. Bilodeau responsable, D. Petitclerc	Physiologie de la lactation
R. Bilodeau responsable, J.J. Matte	Nutrition – porcs
P. Dumoulin responsable, C.L. Girard	Nutrition – jeunes ruminants
G. Guertin responsables, B. Lachance et D. Petitclerc	Nutrition – jeunes ruminants
D. Jannini responsable, P.M. Flipot	Nutrition – bovins de boucherie
P. Lacasse responsables, D. Petitclerc et G. Pelletier	Physiologie de la lactation
M.A. Lalime responsable, A.R. Pesant	Physique des sols
S. Lapierre responsable, L.A. Guilbault	Physiologie de la reproduction
D.M. Marchand responsable, G.L. Roy	Génétique – bovins laitiers
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G. Thibault responsable, P. Savoie	Génie rural
D. Tremblay responsable, P. Savoie	Génie rural
J. Vigneux responsable, A.R. Pesant	Physique des sols
P. Villeneuve responsable, L.A. Guilbault	Physiologie de la reproduction

Étudiants au doctorat

P. Dubreuil responsables, G. Pelletier et D. Petitclerc	Endocrinologie – porcs
C. Pomar responsable, P. Savoie	Zootechnie

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INTRODUCTION

L'année 1987 à la Station de Lennoxville a été marquée par le retour des études et l'arrivée de nouveaux membres du personnel scientifique qui sont venus compléter les équipes de recherches. Il y a eu une restructuration des sections de recherche afin de mieux refléter l'approche par denrée qu'a adopté le Ministère. On a aussi procédé à une réorganisation du centre laitier suite à l'entrée en fonction d'une salle de traite moderne.

La recherche de la Station porte sur cinq programmes principaux : les bovins laitiers, les bovins de boucherie, les porcs, les plantes fourragères et les sols. Des équipes pluridisciplinaires, comportant des spécialistes en génétique, nutrition, physiologie, comportement et régie, travaillent à augmenter l'efficacité des principales productions animales du Québec. Parmi les domaines de pointe dans lesquels oeuvrent les chercheur(e)s de la Station, on retrouve les manipulations hormonales et le transfert d'embryon, deux domaines qui auront un impact certain sur l'industrie animale. La recherche en plantes fourragères vise à augmenter la consommation par le ruminant de cette denrée si abondante au Québec. Des travaux sur la régie des fumiers, la fertilité et l'érosion ont pour objectifs d'augmenter la productivité des sols et d'en empêcher la dégradation.

On peut obtenir des renseignements plus complets en écrivant directement aux chercheur(e)s à l'adresse suivante : Station de recherches, Direction générale de la recherche, Agriculture Canada, C.P. 90, 2000 route 108 Est, Lennoxville, Québec, J1M 1Z3; Tél. (819) 565-9171.

J.C. St-Pierre
Directeur

ANIMAUX D'ABATTAGE

Bovins de boucherie

Effet de la stimulation électrique et du temps de vieillissement sur la dégradation des protéines myofibrillaires de la viande de veau. La dégradation des protéines myofibrillaires de la viande de veau a été évaluée en fonction du temps de vieillissement en chambre froide (4 °C) sur 12 carcasses témoins (T) et 12 carcasses soumises au traitement de stimulation électrique (ES). Les différentes protéines ont été mesurées par densitométrie sur des gels de polyacrilamide en milieu dénaturant. Les résultats démontrent que, avec le temps, la troponine-T (TN-T) se dégrade et disparaît éventuellement; de plus la vitesse de dégradation de cette protéine est ralentie par la stimulation électrique ($P < 0{,}05$). Deux autres protéines (bandes D et P) caractérisées par des bandes plus lourdes que la troponine-I (TN-I), dans la région de 25–30 kdaltons, sont influencées par le temps de vieillissement. Une bande distale à la TN-I (bande D) qui était pratiquement absente à 30 min post mortem est apparue un peu plus rapidement dans la viande des carcasses soumises à la SE; la différence n'était cependant pas significative. Au jour 6 post mortem, la bande D était présente en quantité équivalente dans les deux traitements et se situait à un niveau sept à huit fois supérieur à la mesure prise à 30 min post mortem. L'autre bande, proximale à la TN-I (bande P), était présente en quantité équivalente chez les T et les ES à 30 min post mortem. Ces protéines ont subi une dégradation d'environ 50 % après 6 jours de vieillissement et ce, indépendamment de la ES. Les traitements post mortem ont donc influencé la vitesse de dégradation de ces protéines, spécialement celle de la TN-T. Cependant, au jour 6, l'état de dégradation protéique était similaire selon les traitements.

Porcs

Importance de l'acide folique dans la nutrition de la truie en lactation. Ce travail avait pour but de déterminer l'effet d'injections intramusculaires d'acide folique administrées pendant la lactation sur l'évolution de la concentration en folates sériques des truies et des porcelets, sur les folates du lait ainsi que sur la croissance des porcelets. Chez les truies, un accroissement graduel des folates sériques pendant la lactation a été observé mais cet accroissement a été plus prononcé ($P < 0{,}01$) suite à l'administration d'acide folique. La concentration en folates du lait a diminué

($P < 0{,}01$) entre le jour 7 et le jour 21 de lactation mais elle s'est maintenue à un niveau plus élevé ($P < 0{,}01$) chez les truies recevant un supplément d'acide folique. Chez les porcelets dont les mères n'avaient pas reçu d'acide folique, la concentration en folates sériques s'est accrue de la naissance jusqu'à l'âge de 2 semaines; par la suite, il y eut une diminution graduelle jusqu'au moment du sevrage, 4 semaines après la parturition. Chez les porcelets dont les mères avaient reçu de l'acide folique, l'évolution de la concentration en folates sériques était similaire mais les valeurs étaient supérieures ($P < 0{,}01$) d'environ 15 %. Le taux de croissance des porcelets, de la naissance jusqu'à l'âge de 8 semaines, était semblable ($P > 0{,}47$) selon les traitements.

Facteurs de croissance chez le porc. Nous avons effectué des travaux sur la manipulation de l'hormone de croissance ou somatotropine (ST) au moyen de facteurs hypothalamiques telles la somatocrinine (GRF), la thyréolibérine (TRF) et la somatostatine (SRIF) dans le but d'améliorer l'efficacité alimentaire et la qualité des carcasses des porcs d'engraissement. Les doses de GRF et de TRF qui permettent une libération optimale d'hormones ont été de 27 et 9 $\mu g \cdot kg^{-1}$ de poids corporel, respectivement. Les concentrations sanguines de ST de même que la réponse stimulée au GRF ont diminué avec l'âge. La castration diminue également les niveaux sanguins de ST et sa réponse stimulée au GRF. L'immunisation active contre la somatostatine a permis de doubler les niveaux de base ainsi que les réponses de ST stimulées au GRF en comparaison des animaux témoins. Les résultats indiquent que les manipulations hormonales au moyen de facteurs hypothalamiques pourraient être efficaces pour améliorer l'efficacité de la production porcine.

Effet de l'estrogène sur la croissance et la survie des porcelets. La relation entre la concentration d'estrone chez les porcelets naissants et leur performance pré-sevrage a été étudiée avec 10 (étude 1) ou 7 (étude 2) portées de porcelets Yorkshire. Dans les deux études, nous avons prélevé des échantillons sanguins sur les porcelets à la naissance et à chaque heure pendant les 12 h suivantes. Les premières heures qui suivent la naissance étaient caractérisées par une chute de la concentration d'estrone. Cette diminution est attribuée à la perte du placenta qui est une source importante d'estrogène pendant la gestation. Le sexe du porcelet n'a pas influencé le taux d'estrone. Il n'existait aucune corrélation ($P > 0{,}05$) entre l'estrone et le poids des porcelets à 3 et 5 semaines d'âge. Dans la deuxième étude, la moitié des porcelets de chaque portée ont reçu un implant d'estradiol à la naissance. Les concentrations d'estrone étaient significativement plus hautes chez les porcelets ayant reçu un implant mais ni le gain de poids corporel ni le taux de survie n'ont été améliorés par ce traitement. Il semble donc que la concentration endogène d'estrone chez les porcelets naissants n'est pas reliée à la croissance ou à la survie des porcelets; de même, l'insertion d'un implant d'estradiol à la naissance n'a pas eu d'effet sur ces deux critères de productivité de l'élevage.

Effet d'injections sous-cutanées répétées sur la sécrétion de cortisol sérique chez les truies en lactation. Nous avons utilisé onze truies primipares Yorkshire pour évaluer si des injections sous-cutanées répétées constituent un stress pour l'animal. Ces animaux ont reçu une injection sous-cutanée de saline (derrière le coude) deux fois par jour (10 h 00 et 16 h 00) de 5 à 25 jours post-partum. Des échantillons sanguins ont été prélevés aux 20 min à l'aide d'une canule intra-jugulaire pendant 4 h (8 h 00 à 12 h 00) aux jours 5, 15 et 25 pour le dosage ultérieur du cortisol sérique, qui est un indicateur de stress physiologique et psychologique chez le porc. L'injection sous-cutanée a provoqué un relâchement sanguin de cortisol aux jours 5 et 15, mais aucune augmentation n'a été observée au jour 25. Nous avons également mesuré des concentrations élevées de cortisol dès le premier prélèvement sanguin du jour 5. Cet effet n'a pas été noté lors des 2 jours subséquents de prélèvement. Ces résultats indiquent, qu'au premier jour d'expérience, la manipulation du cathéter à elle seule a été suffisante pour déclencher un relâchement de cortisol sanguin. Cependant, les truies se sont rapidement habituées à cette manipulation puisqu'aux jours 15 et 25, les taux de cortisol n'ont pas augmenté suite aux premiers prélèvements. Par contre, les truies se sont habituées moins rapidement aux injections puisqu'une diminution de la réponse du cortisol n'est apparue qu'au jour 25. Ces résultats suggèrent que toute nouvelle manipulation, même si elle est indolore, pourrait engendrer chez l'animal un certain stress. Cette réaction ne persisterait que dans les cas où les manipulations causent un certain inconfort physique à l'animal, comme c'est le cas avec les injections.

Développement du comportement à la tétée. Durant les trois premiers jours qui suivent la naissance, les porcelets établissent une préférence pour une paire de mamelles. Par la suite, ils deviennent de plus en plus fidèles à cette paire de mamelles préférées tout en diminuant la fréquence des tétées manquées et des disputes aux tétines. Les porcelets qui ne suivent pas ce développement du comportement à la tétée ont un faible taux de croissance. La fréquence des disputes aux mamelles après le troisième jour suivant la naissance pourrait servir à identifier précocement les porcelets ou les portées qui risquent de montrer un retard de croissance. Cet outil de régie permettrait au producteur de porter une attention particulière à ces porcelets ou à leur mère afin de maximiser la productivité de l'éleveur.

PRODUCTION LAITIÈRE

La somatocrinine, la production de lait et l'efficacité alimentaire. Nous avons étudié l'augmentation des sécrétions endogènes de l'hormone de croissance ou somatotropine par l'apport exogène de somatocrinine (GRF) chez la vache laitière. Il a été démontré que l'activité biologique du GRF de 44 acides aminés était comparable à son fragment amide de 29 acides aminés en terme de libération de la somatotropine et de stimulation de la production laitière. En effet, six injections intraveineuses par jour pendant 10 jours du GRF(1–44)NH_2 ou (1–29)NH_2 humains à une dose par injection de 0,2 $nmol \cdot kg^{-1}$ ont augmenté la production laitière de 3,1 et 2,9 $kg \cdot j^{-1}$, respectivement (18,6 et 14,6 %). L'effet d'une injection sous-cutanée quotidienne pendant 10 jours de GRF(1–29)NH_2 (10 mg) a provoqué une augmentation de la production laitière de 3 $kg \cdot j^{-1}$ (14,3 %). Lors de ces deux expériences, il n'y a eu aucun effet des traitements sur la consommation des aliments, ce qui s'est traduit par une augmentation de l'efficacité alimentaire brute (19 et 24 %, expérience 1; 8 %, expérience 2). Nous avons noté une augmentation du pourcentage de gras et une baisse de pourcentage de la protéine dans le lait lors de ces deux expériences de courte durée (10 jours d'injections). L'injection de GRF(1–29)NH_2 humain (10 $\mu g \cdot kg^{-1}$ poids vif) par voie sous-cutanée au cours des deux derniers mois de la lactation a permis récemment d'augmenter de 2,0 $kg \cdot j^{-1}$ la production laitière corrigée à 4 % de matière grasse sans affecter la composition du lait et la consommation d'aliment. Par conséquent, l'efficacité alimentaire brute a été améliorée de 9,5 %. Durant la période d'injection, tous les paramètres du profil métabolique des vaches injectées au GRF(1–29)NH_2 ont été normaux à l'exception d'une baisse des taux sanguins de calcium et de cholestérol et d'une augmentation des acides gras libres. Ces vaches ont eu subséquemment une lactation normale après avoir donné naissance à des veaux en santé. Un traitement à long terme avec la somatocrinine (1–29)NH_2 en injection quotidienne permet donc d'augmenter la production laitière et d'améliorer l'efficacité alimentaire sans modifier la composition du lait.

Surovulation par infusion continue d'hormone folliculo-stimulante (FSH-P) chez le bovin. Au jour 10 du cycle oestral, des vaches laitières ont été réparties en deux traitements. Les vaches d'un traitement ($n = 6$) ont été surovulées selon la méthode conventionnelle, c'est-à-dire que la FSH-P (32,7 mg) était injectée deux fois par jour en doses décroissantes pendant 4,5 jours. Les vaches de l'autre traitement ($n = 6$) ont d'abord reçu deux injections de FSH-P (5,3 et 4,6 mg) à 12 h d'intervalle. Par la suite, la FSH-P a été infusée de façon continue (441,7 µg/h) pendant 84 h directement dans l'aorte dorsale via un cathéter inséré dans l'artère caudale. L'oestrus a été induit dans les deux groupes par une injection de cloprostenol (625 µg) 3,5 jours après le début du traitement de surovulation et les vaches ont été inséminées artificiellement. Les embryons ont été recueillis par lavage utérin 7 jours après l'oestrus et la réponse ovulatoire a été évaluée par échographie. Les concentrations de progestérone ont été déterminées à partir d'échantillons de sang prélevés pendant la phase expérimentale. Le nombre d'ovulations (13,3 ± 1,8 vs 8,3 ± 1,9) et d'embryons ou d'ovules non fécondés (13,8 ± 2,9 vs 6,2 ± 2,1) ainsi que les concentrations maximales de progestérone entre l'oestrus et le jour de la récolte des embryons (37,4 vs 18,0 $ng \cdot mL^{-1}$) étaient inférieurs pour les vaches infusées que pour celles injectées. Par contre, l'examen échographique a démontré que la proportion de follicules non ovulés au jour 7 après l'oestrus était plus élevée sur les ovaires des vaches infusées que sur les ovaires de celles qui avaient été injectées. Donc, par rapport à la méthode conventionnelle par injection, la surovulation par infusion continue de FSH-P diminue la production d'embryons et cet effet négatif est associé à la présence d'une proportion élevée de follicules non ovulés. Ces résultats suggèrent qu'une relâche lente et prolongée de FSH n'assure pas nécessairement le succès de la surovulation. Des travaux portant sur le mode d'administration de la FSH seraient encore nécessaires avant d'envisager la mise au point d'un implant de FSH.

Profil des concentrations de folates sériques pendant la période d'élevage des veaux de lait. Soixante-deux veaux ont été utilisés pour étudier l'évolution du profil des folates sériques pendant la croissance de veaux de lait nourris exclusivement de lactoremplaceurs commerciaux contenant 1,1 mg d'acide folique par kilogramme de lactoremplaceur. Lors de cette étude, effectuée dans une ferme commerciale, des prélèvements sanguins ont été effectués chez tous les veaux, à toutes les 2 semaines, de l'entrée à l'étable à l'âge de 5 à 10 jours, jusqu'à l'abattage, 110 jours plus tard. Il y a eu des variations significatives ($P < 0,0001$) de la concentration des folates sériques pendant cette période. La concentration de folates sériques a diminué pendant les 3 premières semaines d'élevage, passant de 11,3 à 5,1 $ng\cdot mL^{-1}$, a augmenté ensuite à 23,8 $ng\cdot mL^{-1}$ à 5 semaines, puis s'est stabilisée à environ 14 $ng\cdot mL^{-1}$ jusqu'à la fin de la période d'élevage. Il semble donc que la concentration de 1,1 mg d'acide folique par kilogramme de lactoremplaceur a été suffisante, sauf en début d'élevage, pour maintenir la concentration des folates sériques des veaux de lait au même niveau que celle des bovins adultes, généralement considérés comme n'ayant aucun besoin en acide folique provenant de la diète.

Digestibilité et paramètres sanguins chez le veau préruminant recevant un lactoremplaceur coagulable ou non-coagulable. Huit veaux mâles Holstein âgés de 7 à 10 jours ont reçu un lactoremplaceur contenant ou non une solution tampon oxalate-NaOH qui prévient la coagulation du lait. Ces veaux ont été répartis au hasard en deux groupes afin d'étudier l'effet de la coagulation du lait sur la digestibilité et les paramètres sanguins. Les concentrations plasmatiques de glucose et d'insuline ont été semblables ($P > 0,05$) pour les deux groupes. Dans les deux cas, les concentrations de glucose et d'insuline ont atteint un maximum 2 h après le repas ($P < 0,05$). Les concentrations plasmatiques de triglycérides ont été plus élevées ($P < 0,01$) après que les veaux aient reçu le lactoremplaceur non-coagulable comparativement au lactoremplaceur coagulable. Les concentrations d'acides aminés essentiels et d'urée plasmatiques ont été plus élevées pour le lactoremplaceur non-coagulable ($P < 0,01$). La digestibilité de la matière sèche, de l'azote et des lipides a été semblable ($P > 0,05$) pour les deux groupes. Nous avons émis l'hypothèse que la coagulation du lait influence les concentrations plasmatiques de triglycérides, d'acides aminés essentiels et d'urée sans modifier la digestibilité du régime.

EXPLOITATION DES PLANTES FOURRAGÈRES

Ingestion volontaire et digestibilité de la fléole. Nous avons mesuré l'ingestion volontaire et la digestibilité de la matière sèche de cinq cultivars de fléole (Clair, Champ, Milton, Climax et Bounty) à la suite d'une expérience sur cinq jeunes béliers. Les cinq cultivars ont été récoltés au stade de première floraison et à la repousse. L'ingestion volontaire du cultivar Champ, un cultivar hâtif, a été supérieure de 10 % à celle du cultivar Climax, un cultivar semi-tardif. L'inverse a été noté avec la repousse. Nous n'avons observé aucune différence significative de digestibilité entre les cultivars au stade de première floraison. Les cultivars Champ, Milton et Bounty contenaient plus de protéines que les cultivars Climax et Clair. Le cultivar Champ contenait moins de lignocellulose (ADF) que les cultivars Milton et Climax; il contenait aussi moins de constituants de parois cellulaires (NDF) que les cultivars Milton, Clair et Climax.

Effet des additifs alimentaires sur l'activité phosphatasique. Des travaux sur la minéralisation du phosphore organique contenu dans le fumier ont démontré que les additifs des aliments du bétail peuvent produire des effets significatifs sur l'activité phosphatasique. Les réponses aux doses employées dans les moulées ont été complexes : la bacitracine et la pénicilline de sodium ont augmenté l'activité phytasique sur la minéralisation de l'inositol hexaphosphate (un des phosphores organiques dans le fumier) tandis que la lincomycine et la néomycine ont inhibé cette activité.

Érosion du sol et des éléments fertilisants sur quatre systèmes de culture. Nous avons comparé les quantités de sol érodé et d'éléments fertilisants (nitrates, phosphore et potassium) entraînées au bas d'une pente de 9 % sur quatre systèmes de culture pratiqués au Québec : une prairie permanente de luzerne-mil; une jachère traitée à l'atrazine pour contrôler les mauvaises herbes; un champ de maïs ensilage semé après un labour d'automne et un hersage printanier; un ensemencement de maïs sur une prairie sans travail du sol où toute végétation avait été détruite par une application d'atrazine à la dose de 4,5 $kg \cdot ha^{-1}$. Nous avons noté des différences significatives ($P < 0,01$) entre les quatre systèmes de culture pour la perte de sol et l'eau ruisselée. L'érosion a été plus élevée sur la jachère que sur le champ de maïs ensilage, la culture de maïs sans travail du sol et la prairie permanente puisque l'eau de pluie perdue par ruissellement a été de 19, 10, 3,5 et 2,3 % respectivement. La quantité de sol érodé a été la plus faible sur la prairie permanente avec un facteur récolte (Facteur-C) de moins de 1 % comparativement à 3 % pour le maïs cultivé sans travail du sol et à 40 % pour le maïs cultivé de façon conventionnelle. Les pertes en N-NO_3, P et K ont été réduites selon l'ordre décroissant qui suit : maïs conventionnel > jachère > mais sans travail du sol > prairie permanente.

Les films de polyéthylène à ensilage. La qualité des films de polyéthylène pour recouvrir l'ensilage se détériore avec le temps. Nous avons observé que la résistance à l'impact diminuait de 2 à 3 % par mois d'exposition aux intempéries. Le plastique usagé avait tendance à être plus cassant que le plastique neuf. Une perforation de 1 cm de diamètre à la surface du polyéthylène occasionnait le développement de moisissures dans l'ensilage sur un rayon de 30 cm après 4 mois. Un modèle théorique décrivant l'infiltration d'air a été mis au point pour optimiser le coût du plastique et le coût des pertes d'ensilage. D'après le modèle, les épaisseurs disponibles sur le marché de 100, 150 et 200 µm (4, 6 et 8 millièmes de pouce) sont optimales pour recouvrir des silos-meules durant 3, 7 et 12 mois, respectivement. Pour des durées d'entreposage intermédiaires, il serait souhaitable de choisir l'épaisseur plus élevée que l'épaisseur optimale afin de tirer avantage de la plus grande résistance au déchirement et à la perforation des films plus épais.

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INTRODUCTION

En 1987, la Station de recherches de Sainte-Foy a poursuivi ses efforts vers la consolidation des travaux de recherches afin d'en accroître l'efficacité. Ainsi, plusieurs expériences effectuées aux fermes expérimentales de La Pocatière et de Normandin, sous la direction de chercheurs de la Station, ont été transférées près des lieux d'affectation des responsables. Nous avons loué quelque 30 ha de terrain à Lévis en plus de continuer l'aménagement de la ferme Jean-Charles Chapais à Saint-David. La deuxième phase des travaux de construction à La Pocatière est terminée et la construction d'une nouvelle bergerie a débuté.

Les travaux de recherches sont orientés vers les productions fourragères, céréalières, ovines, bovines, horticoles dont la pomme de terre, ainsi que les sols. Pour de plus amples renseignements, s'adresser à : Station de recherches, Agriculture Canada, 2560 boul. Hochelaga, Sainte-Foy, Québec, G1V 2J3; Tél. (418) 657-7980.

S.J. Bourget
Directeur

LES PLANTES FOURRAGÈRES

Amélioration génétique des légumineuses

Amélioration du trèfle rouge. Nous avons expérimenté à Sainte-Foy et au collège Macdonald un nombre important de cultivars européens et nord-américains. La croissance de chaque cultivar a varié grandement durant l'année d'implantation. Les cultivars nord-américains ont montré beaucoup plus de vigueur et de résistance aux maladies foliaires et aux insectes.

Résistance à la pourriture du collet. Nous avons obtenu d'excellents résultats avec deux nouvelles lignées de luzerne et de trèfle rouge sélectionnées pour leur résistance à la pourriture du collet au cours d'essais en parcelles. La lignée de luzerne est présentement intégrée dans le programme général d'amélioration à la Station. La lignée de trèfle rouge sera soumise à l'évaluation comparative au champ dans les essais réguliers de cultivars du Conseil des productions végétales du Québec.

Cultivar expérimental de luzerne. À Indian Head, en Saskatchewan, nous avons établi une parcelle de semence provenant de sélectionneur afin de procéder à la multiplication du cultivar expérimental de luzerne SF-8001. Ce cultivar créé à Sainte-Foy est de type semi-hâtif et possède un meilleur rendement et une persistance supérieure au cultivar Saranac. Une demande d'enregistrement pour ce cultivar sera effectuée lorsque la semence de sélectionneur sera disponible en quantité suffisante.

Résistance à la verticilliose. Nous avons accéléré la sélection de luzernes au champ et en laboratoire afin de développer des populations de cette plante résistantes à la verticilliose. On a produit de la semence de génération syn-1 à partir de quatre populations dont le niveau de résistance varie de modérément sensible à résistant.

Amélioration génétique des graminées

Parois cellulaires de l'alpiste roseau. La sélection pour une faible teneur en parois cellulaires (NDF) chez l'alpiste roseau (*Phalaris arundinacea* L.) est associée à une épiaison tardive, tandis que la sélection pour un NDF élevé est fonction de l'hâtivité de l'épiaison. Dans l'ensemble, il n'y a pas de relation entre la sélection pour le rendement en matière sèche et la sélection pour le NDF chez cette espèce; la sélection pour ces deux critères permet de créer des populations divergentes. Il faut plus d'un cycle de sélection pour obtenir des populations d'alpiste roseau dont le rendement en matière sèche et en NDF soit supérieur à la population initiale.

Propriétés physiques du fourrage de la fléole. L'ingestibilité d'un fourrage par les ruminants est reliée à la rétention d'eau, la solubilité à l'eau et au volume compacté du fourrage. Une étude effectuée avec quatre populations de fléole des prés montre des variabilités génétiques pour ces trois propriétés physiques lorsque les plants de fléole sont récoltés au début de l'épiaison et à la floraison. Ces trois propriétés s'améliorent à mesure que la fléole prend de la maturité. Étant donné que les interactions entre les génotypes, les années de récolte et les stades de maturité, sont importantes, il nous faudra utiliser différentes stratégies pour évaluer ces paramètres dans un programme d'amélioration génétique de la fléole.

Malherbologie

Démographie du chiendent. En collaboration avec d'autres centres de recherches, nous avons entrepris un projet qui a pour but de mettre au point un modèle démographique du chiendent (*Agropyron repens* L.). Ce modèle permettra de mieux comprendre la dynamique de population de cette espèce et de mieux guider les interventions de désherbage.

Compétition spargoute-luzerne. Nous avons identifié les mécanismes de compétition entre la spargoute des champs (*Spergula arvensis* L.) et la luzerne au cours des premiers stades de leur croissance. On a mené cette étude en serre à l'aide de boîtes de compétition qui permettaient de distinguer les phénomènes de compétition aérienne et souterraine. Après 26 jours de croissance, la spargoute était déjà affectée par la présence de la luzerne. Il n'a pas été possible d'identifier quelles étaient les ressources impliquées puisque des densités de mauvaises herbes atteignant 600 plants/m^2 n'ont pas eu d'effet sur la culture. Cependant, l'expérience a été de courte durée et, comme la spargoute des champs peut affecter sensiblement la croissance de la luzerne, l'effet négatif de la spargoute des champs ne survient qu'après cette période de 26 jours. Il est donc possible d'attendre 4 semaines avant d'effectuer une intervention de désherbage.

Exploitation

Repos automnale de la luzerne. Les résultats préliminaires d'un essai de régie automnale de la luzerne mené à cinq sites indiquent que la période de repos automnale débute environ 10 jours plus tôt que celle décrite actuellement pour la région; la date cible serait le 15 août pour la région de Québec, avec des écarts de plus ou moins 10 jours pour les régions nordiques de la province et pour la région de Montréal respectivement.

Évaluation de cultivars

Essais de cultivars de luzerne et de ray-grass annuel. L'évaluation de cultivars de luzerne et de ray-grass annuel (*Lolium multiflorum* Lam.) pour le Québec s'est poursuivie en 1987 avec l'aide des stations coopérantes. Les cultivars de luzerne Ambassador, Minto, Mohawk, Oneida VR, Spectrum, WL 316, 5444 et 88 et le cultivar de ray-grass annuel Bartolini ont été ajoutés à la liste des cultivars recommandés pour le Québec en 1988.

LES CÉRÉALES

Pathologie

Fusariose. La croissance in vitro du *Fusarium graminearum*, agent de la fusariose, a été nettement stimulée par des extraits d'anthères de la lignée de blé résistante Nobeoka Bozu. Toutefois, il n'y avait aucune croissance du champignon pathogène en présence d'extraits d'anthères du cultivar sensible Laval 19. La réceptivité particulière du blé au *F. graminearum* lors de la floraison serait donc liée à des facteurs autres que les anthères.

Moisissures nivéales. La production in vitro de sclérotes du *Typhula ishikariensis*, un agent des moisissures nivéales, est directement proportionnelle à l'épaisseur du milieu de culture dans les boîtes de Pétri alors que la vitesse de croissance du champignon reste à peu près inchangée. De plus, nous avons constaté la présence au Québec d'un autre agent des moisissures nivéales chez les céréales d'automne, le *Typhula incarnata*.

Épidémie de VJNO. Pour la seconde année consécutive, les céréales de printemps ont été affectées par le virus de la jaunisse nanisante de l'orge (VJNO) au Québec. Les deux cultivars d'avoine Nova et Capital, créés à la Station, ont prouvé leur excellente résistance au champ, tandis que les cultivars sensibles ont subi des pertes atteignant 50 % dans la région de Québec. Nous avons observé une mauvaise tolérance au VJNO chez le cultivar d'orge Birka ainsi que chez les cultivars de blé panifiable Columbus, Max et Katepwa. Chez le blé d'automne, l'épidémie de VJNO est apparue à la fin du printemps, ce qui est inhabituel; l'infection survient normalement à l'automne. Les épis de blé infectés de VJNO étaient prédisposés à une forte contamination de champignons pathogènes et les grains de ces épis étaient de piètre qualité.

Amélioration génétique

Programme d'amélioration. En 1987, nous avons ralenti le cours de recherches sur l'amélioration de l'avoine et du triticale ce qui nous a permis d'augmenter les travaux d'amélioration du blé panifiable et de l'orge de printemps. Toutefois, les travaux reliés à l'évaluation, à l'enregistrement et à la recommandation de nouveaux cultivars de ces quatre espèces céréalières se poursuivent.

Le cultivar d'avoine Capital. Le nouveau cultivar d'avoine Capital, créé à la Station de Sainte-Foy, est enregistré au Canada depuis 1987. Ce cultivar, de maturité moyenne, est très bien adapté au Québec, produit les plus hauts rendements en grains et a une tolérance supérieure au VJNO.

Orge. Les recherches sur la lignée d'orge Q.B.198.27, créée à Sainte-Foy, se poursuivent en vue de son enregistrement par la Comité des céréales du Conseil des productions végétales du Québec et par le Comité d'experts de l'Est sur les céréales et les oléagineuses. Cette lignée prometteuse est caractérisée par une productivité très élevée, une courte paille de force supérieure, de gros grains et une tolérance élevée au VJNO. De plus, cette lignée est très tolérante à l'acidité des sols ce qui permettra de l'incorporer dans une rotation avec les pommes de terre.

Blé panifiable. Plus de 11 000 lignées de blé à potentiel panifiable ont été sélectionnées parmi 490 croisements réalisés depuis 1982. Une de ces lignées précoces qui démontre une bonne performance dans les essais d'enregistrement laisse présager l'inscription d'un cultivar de blé panifiable adapté pour les régions périphériques.

Triticale. La maturité tardive du triticale demeure un problème. Toutefois, les lignées hâtives de triticale sélectionnées à la Station offrent des rendements supérieurs au blé et démontrent une précocité égale.

Croisements intergénériques. Deux nouvelles espèces ont été croisées au blé : *Leymus innovatus* et *Psathyrostachys juncea.* Nous avons mis au point une nouvelle technologie permettant la culture de pro-embryons. Le blé a été rétrocroisé avec l'hybride *T. aestivum* × *L. innovatus.* Ces hybrides démontrent une vigueur et une rhizogénèse exceptionnelles. Des études sont en cours pour mesurer l'expression des gènes de résistance aux maladies, aux virus, au froid et à la salinité chez les hybrides et les rétrocroisements.

LES SYMBIOSES VÉGÉTALES

Endomycorhizes

Inoculation de plants de poireau. Une étude a été entreprise afin d'évaluer les effets de doses croissantes de phosphore sur la physiologie des champignons endomycorhiziens et sur la croissance des plants de poireau (*Allium porrum* L.). À la récolte, les plants de poireau inoculés avaient une taille supérieure à celle des plants témoins non mycorhizés, et cela quelles que soient les doses de phosphore qui variaient de 0 % à 150 % selon les recommandations provinciales. Parallèlement, sur une exploitation agricole à Saint-Hyacinthe, nous avons effectué au champ un essai de transplantation de plants de poireau endomycorhizés sur une superficie de 0,5 ha, une première canadienne. Bien que l'évaluation de la rentabilité d'une telle pratique soit en cours, nous avons constaté qu'en plus d'avoir une croissance accrue, les plants de poireau endomycorhizés entreposés à basse température se conservent mieux que les plants témoins.

Fixation d'azote

Survie du rhizobium produit avec le lactosérum. Suite à l'utilisation d'un milieu de culture à base de lactosérum pour la production massive de *Rhizobium meliloti*, les recherches subséquentes ont permis d'établir que les cellules de *Rhizobium* développées sur le lactosérum avaient un taux de survie de 85 %, lorsque congelées à − 18 °C, comparativement à 35 % et 2 % pour les cellules développées sur le sucrose et le mannitol. Après avoir employé des solutions protectrices, nous avons constaté que le lactosérum constituait une excellente solution protectrice puisque les cellules de *Rhizobium* développées sur le mannitol et ayant un taux de survie à la congélation de 2 % voyaient ce taux augmenter à 94 % si ces cellules lavées étaient resuspendues dans le lactosérum. Toutefois, les cellules développées sur le lactosérum et resuspendues dans du mannitol avaient un taux de survie de 61 %. Sachant que le *Rhizobium* est vendu sur le marché sous forme d'inoculants commerciaux, une étude similaire a été entreprise avec des cellules ensachetées soumises à des stress hydriques et de température. Les résultats démontrent que les cellules de *Rhizobium* développées sur le lactosérum ont un taux de survie supérieur aux cellules développées sur le mannitol. Après 23 semaines d'entreposage, la population finale de bactéries infectives de plants de luzerne était trois fois supérieure dans les sachets contenant les cellules développées sur le lactosérum.

Rhizobactéries

Rhizosphère du maïs. Nous avons entrepris cette année des études sur l'interaction de la microflore rhizosphérique dans la production des céréales. Nous avons isolé plus de 600 bactéries des racines de plus de 20 cultivars de maïs et, de ce nombre, 15 % ont été des bactéries endoracinaires. Des études menées en serres ont permis de déterminer des isolats qui peuvent augmenter le rendement du maïs après 6 semaines de croissance.

Fixation d'azote à basse température. Des souches de *Rhizobium* isolées des nodosités de trois légumineuses arctiques indigènes à la Péninsule de Melville, dans les Territoires du Nord-Ouest, nodulent efficacement une légumineuse fourragère tempérée, le sainfoin (*Onobrychis viciifolia* Scop.). Dans un sol complètement dépourvu d'azote minéral, l'efficacité symbiotique de huit souches arctiques, mesurée par le rendement en matière sèche de la partie aérienne du sainfoin, a été similaire à celle obtenue avec des souches de référence originaires du sainfoin et utilisées dans les inoculants commerciaux. En présence de faibles doses d'azote minéral (30 mg/L N-NO_3), six souches arctiques ont donné des rendements plus élevés que les souches de référence. Aux basses températures, les souches arctiques ont donné une meilleure croissance bactérienne et une plus grande activité de la nitrogénase avec le sainfoin que les souches de référence. Les résultats indiquent également que le *Rhizobium* influence l'expression de l'activité fixatrice d'azote du système symbiotique en accroissant l'efficacité à basse température. De plus, la forme et l'arrangement des bactéroïdes des nodules du sainfoin diffèrent selon qu'ils sont formés par une souche arctique ou une souche isolée du sainfoin. Une des souches arctiques modifie la structure interne des nodules du sainfoin et cette modification peut rendre la plante hôte plus efficace à fixer l'azote à basse température. Le catabolisme du glucose indique que les souches arctiques ressemblent au genre *Rhizobium*, mais d'autres activités métaboliques les apparentent au genre *Bradyrhizobium*. Les deux meilleures souches arctiques sont actuellement en essai au champ à la Station de Swift Current, en Saskatchewan, afin d'évaluer si elles peuvent être utilisées comme inoculants avec le sainfoin.

PHYSIOLOGIE ET BIOCHIMIE DES PLANTES

Mécanismes de résistance au froid

Régulation des niveaux de polyamines. Les polyamines sont des molécules impliquées dans la synthèse de protéines et d'acides nucléiques ainsi que dans la stabilisation des membranes plasmiques. Nous avons émis l'hypothèse que ces composés soient des régulateurs de croissance endogènes dont le métabolisme est très affecté par les conditions environnementales. Une étude a permis de déterminer les variations des niveaux de polyamines chez le blé, le seigle, la fléole des prés et la luzerne lors de l'endurcissement au froid dans deux régions différentes par leur climat, soit à Saint-Hyacinthe et à La Pocatière. Les résultats montrent une augmentation de la putrescine chez les céréales et la fléole durant l'endurcissement au froid jusqu'à la reprise de la croissance au printemps; les plus hauts niveaux de putrescine sont atteints lors du maximum d'endurcissement et au début de la période de désendurcissement. Toutefois, la putrescine n'augmente que très peu chez la luzerne; le niveau maximum chez cette espèce (300–350 nmol/g de poids frais) est inférieur à celui observé chez le blé (750 nmol/g de poids frais), le seigle (650–750 nmol/g de poids frais) et la fléole (450 nmol/g de poids frais). Le contenu en spermine demeure faible et ne varie que très peu chez toutes les espèces. Les niveaux de spermidine varient au cours de l'automne et de l'hiver sans montrer d'accumulation majeure, sauf chez la luzerne où les niveaux de spermidine sont supérieurs à ceux de la putrescine. Cette étude a permis de constater que les températures basses constituent le facteur le plus déterminant pour l'accumulation des polyamines, notamment pour la teneur en putrescine dont l'augmentation est corrélée de façon significative avec le niveau d'endurcissement au froid atteint chez la plupart des espèces évaluées.

Dosage des sucres solubles et de l'amidon. À la suite d'une période d'endurcissement au froid, nous avons procédé à l'analyse des sucres solubles par chromatographie liquide à haute performance (HPLC) et la mesure de l'amidon par colorimétrie chez la luzerne, le blé, le seigle, l'avoine et la fléole des prés. Après 4 jours d'exposition au froid (+2 °C), il y a une accumulation majeure de sucrose dans les couronnes de luzerne qui atteint 6 à 7 fois le niveau initial pour se stabiliser par la suite; peu de variations sont observables pour les teneurs en fructose et en glucose. Par contre, chez les céréales et la fléole, les niveaux de glucose et de fructose augmentent de 2 à 4 fois au cours de l'endurcissement au froid; quoique faible, la teneur en sucrose augmente légèrement, notamment chez le seigle et l'avoine. Chez toutes les espèces étudiées, l'amidon présente une baisse entre le quatrième et le dixième jour de traitement au froid pour augmenter progressivement par la suite. Bien que les sucres solubles et l'amidon s'accumulent chez toutes les espèces étudiées durant une exposition au froid, il n'est pas certain que les niveaux de ces composés puissent être utilisés comme indicateur d'endurcissement au froid ou comme marqueur de rusticité.

Test sur la tolérance au gel

Évaluation en serre de la rusticité des plantes. Une méthode d'évaluation en serre de la rusticité des céréales d'automne a été mise au point afin de reproduire en tout temps les conditions naturelles d'évaluation au champ. Les plants croissent dans des pots disposés sur une table à températures contrôlées. Cinq cycles successifs de gel et de dégel sont appliqués pendant 10 semaines au cours des mois de janvier, février et mars; chaque cycle comprend une semaine de gel (−3 °C à −7 °C) suivie d'une semaine de dégel (1 °C à 3 °C). En plus d'être économiquement avantageuse, cette méthode permet d'évaluer de grandes populations de plants, peu importe les conditions climatiques hivernales.

Comportement des plantules de céréales. Dans le but d'étudier les mécanismes de l'endurcissement au froid, nous avons soumis des plantules d'orge, de blé et de seigle à des traitements d'endurcissement au froid et à la sécheresse. Nous avons noté des changements provoqués par ces traitements au niveau des lipides et des protéines dans les plantules. Les jeunes feuilles primaires de seigle sont capables d'acquérir de la tolérance au gel aussi bien à la suite d'une sécheresse que d'une exposition au froid, mais l'orge et l'avoine acquièrent beaucoup moins de tolérance au gel après la sécheresse qu'après l'acclimatation au froid. Les protéines et les lipides augmentent d'une façon générale chez un grand nombre de plants après un stress. Dans cette étude, nous avons observé des augmentations de lipides, mais elles n'étaient pas en relation avec le degré de tolérance au gel. Quelques-unes des fractions protéiques chez l'orge ont augmenté durant l'acclimatation au froid et le stress de sécheresse, mais elles n'étaient pas reliées systématiquement à la tolérance au gel; une ou peut-être deux protéines semblaient être reliées à la sécheresse chez l'orge seulement. Ce résultat indique un comportement particulier de l'orge en ce qui concerne la sécheresse. Par contre, nous n'avons pas observé des changements biochimiques semblables pour le seigle et l'avoine.

Métabolisme azoté

Efficacité de l'utilisation de l'azote chez la fléole. Une étude a été entreprise récemment afin d'étudier l'effet des doses d'azote minéral sur la distribution de l'activité enzymatique de la nitrate réductase dans diverses parties de plants de fléole de maturité différente. Ces travaux permettront d'identifier les tissus qui peuvent indiquer le potentiel d'utilisation de l'azote dans les cycles de sélection d'un programme d'amélioration génétique. Un grand intérêt est aussi porté à la mise au point d'un système rapide, peu coûteux et fiable permettant l'évaluation de l'activité de cette enzyme dans les tissus végétaux prélevés au champ.

LES SOLS

Fertilisation

Dynamique du K et du Mg dans les sols du Québec. L'horizon de surface (couche de labour) de 30 sols les plus représentatifs de chaque région agricole du Québec ont été échantillonnés dans le but de déterminer leur capacité à fournir à long terme les quantités de K et de Mg nécessaires au maintien des rendements de luzerne. Les résultats préliminaires montrent des différences très marquées entre les sols en ce qui a trait à leurs teneurs en K et Mg assimilables par les plants. De plus, des différences de teneurs en K et Mg sous forme non échangeable ont été notées entre les sols en fonction de leur origine géomorphologique. Un essai en milieu contrôlé ainsi que d'autres analyses chimiques et minéralogiques seront entrepris afin de mieux caractériser la dynamique de la libération du K et du Mg dans les sols de la province.

Phosphore et potassium chez le blé. Nous avons étudié en serres les effets de quatre doses de phosphore (0–60 mg/kg de sol) et de potassium (0–150 mg/kg de sol) sur les rendements des cultivars de blé Casavant, Messier, Mondor et Laval 19 récoltés à deux reprises. Dans l'ensemble, tous les cultivars de blé ont mieux répondu aux apports croissants de P qu'aux apports croissants de K, surtout à la première récolte de grains. En absence de P ou de K, le cultivar Casavant s'est mieux comporté que les autres cultivars. Les rendements moyens des cultivars de blé ont varié d'une récolte à l'autre. Le cultivar Messier a donné le meilleur rendement (9,0 g par pot) à la première récolte tandis que le cultivar Casavant a été le plus productif (6,1 g par pot) à la seconde récolte; le cultivar Mondor a été le moins productif (7,2 g par pot) à la première récolte et le Messier (4,7 g par pot) à la deuxième récolte.

Physique et conservation

Stabilité structurale des sols en fonction des cultures exploitées. L'étude visant à déterminer les effets de la culture de l'orge, du maïs et de la luzerne sur la structure de l'argile Kamouraska, un sol susceptible à la dégradation, a permis de constater qu'après une deuxième saison d'exploitation, les cultures d'orge et de luzerne ont amélioré considérablement la stabilité structurale du sol en comparaison avec le sol retenu pour la culture du maïs et le sol maintenu en jachère. De plus, nous avons enregistré des augmentations de la teneur en polysaccharides du sol lorsque nous avons cultivé l'orge ou la luzerne; nous avons noté une corrélation significative entre la stabilité structurale du sol et sa teneur en polysaccharides. Cette étude se poursuit afin de caractériser cette relation entre la stabilité structurale du sol et sa teneur en polysaccharides.

FERME EXPÉRIMENTALE, LA POCATIÈRE

Les plantes fourragères

Survie à l'hiver. Une étude entreprise sur la productivité des monocultures et des mélanges fourragers a permis de constater un effet positif de la fléole sur la survie hivernale du trèfle rouge. Lorsque l'hiver est propice à la survie des légumineuses, la densité de plants de trèfle rouge est plus élevée dans une population pure de trèfle. Toutefois, quand l'hiver est rigoureux, la population de trèfle rouge est plus élevée en présence de la fléole.

Importance du pissenlit dans les prairies. Les résultats de l'inventaire des mauvaises herbes au Québec montrent que le pissenlit (*Taraxacum officinale* Weber) est présent dans plus de 80 % des prairies. Les infestations dans les prairies établies ne sont graves que dans 24 % des cas; ces infestations se retrouvent surtout dans les prairies de plus de 2 ans. La densité est à son maximum à la fin août et diminue par la suite; dans un des champs inventoriés, jusqu'à 2 134 plantules par mètre carré ont été dénombrées. Au début d'octobre, il ne reste que 22 % de la population de la fin août.

Essais de cultivars de dactyle. L'évaluation de cultivars de dactyle pour le Québec s'est poursuivie en 1987 avec l'aide des stations coopérantes. Il n'y a pas eu d'ajout à la liste des cultivars recommandés de dactyle pour le Québec en 1988.

Horticulture

Amélioration de la pomme de terre. L'évaluation de 14 000 lignées de pomme de terre produites en 1984 et en 1985 a été effectuée au champ cette année, et 8 % de celles-ci ont été sélectionnées. L'évaluation au stade de quatre buttes des lignées sélectionnées antérieurement à Frédéricton et à La Pocatière a permis de retenir 16,5 % et 21,0 % des lignées respectivement pour les évaluations de rendement, teneur en matière sèche, cuisson à l'eau et croustille. Toutes les lignées produites à la Ferme expérimentale et nommées LP87 sont actuellement en épuration au Centre de certification et d'épuration des pommes de terre à La Pocatière. Les lignées LP8047, LP8058 et LP8120 ont été multipliées au Centre provincial de multiplication de semence de Manicouagan.

Cultures fruitières et ornementales

Arbres fruitiers. Les cultivars de prunier Peach Plum et Victoria produisent mieux sur un sol lourd tandis que le cultivar Mont-Royal rend plus sur un loam graveleux. Le cultivar de prunier Reine-Claude continue à donner de bons rendements alors que la productivité du cultivar Veeblue tend à diminuer. Les cultivars de poirier Clapps, Menie et Phileson ont donné de bons rendements comparativement au cultivar Miney dont la productivité a été moyenne.

Arbres et arbustes ornementaux. Près de 3 100 arbres et arbustes sont évalués pour leur adaptation et leur résistance aux maladies; nous avons transplanté 840 nouveaux spécimens en 1987. Bien que les arbres et arbustes transplantés en 1986 aient souffert d'un drainage inapproprié, les plantations antérieures ont démontré une bonne croissance.

FERME EXPÉRIMENTALE, NORMANDIN

Les plantes fourragères

Essais de cultivars de trèfles. L'évaluation de cultivars de trèfle rouge et de trèfle blanc s'est poursuivie en 1987. Le cultivar de trèfle rouge Persist a été ajouté tandis que le cultivar Dollard a été retiré de la liste des cultivars recommandés pour le Québec en 1988; la liste des cultivars recommandés de trèfle blanc est demeurée inchangée.

Les céréales

Amélioration du blé. La poursuite du programme d'amélioration du blé de printemps vise le développement de lignées hâtives possédant un potentiel de rendement élevé. En 1987, 19 lignées ont été évaluées en préliminaire tandis que 10 et 5 lignées étaient évaluées respectivement en tamisage et en essai coopératif de l'Est.

Régie. De nouvelles études sur la régie des céréales ont débuté afin de déterminer la productivité de différents mélanges d'orge et d'avoine et l'influence des espèces fourragères sur le rendement de l'orge utilisée comme plante-abri. La régie intensive de l'orge est également étudiée. Ainsi, l'utilisation d'un régulateur de croissance, d'un fongicide, d'un écartement réduit entre les rangs et des taux de semis élevés sont autant de facteurs qui sont présentement évalués.

Ergot des céréales. Cette maladie fongique prend de l'ampleur dans la région du Saguenay-Lac Saint-Jean. Afin de mieux comprendre les facteurs qui favorisent cette maladie, on a entrepris des travaux afin de déterminer la susceptibilité des différents cultivars d'orge à l'ergot et l'influence de la date et du taux de semis sur le développement de l'agent pathogène.

La nutrition animale

Longueur de hachage de l'ensilage d'herbe. Nous avons amorcé cette année une étude dans le but de vérifier si les performances de la vache laitière sont différentes lorsqu'elle reçoit un régime alimentaire à base d'ensilage d'herbe coupé à 6,3, 12,7, 25,4 ou 38,1 mm de longueur.

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Station de recherches Saint-Jean-sur-Richelieu, Québec

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[2] S'est joint au personnel en 1987.

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INTRODUCTION

La Station de recherches de Saint-Jean-sur-Richelieu sert l'industrie horticole en recherche sur la production et la protection regroupées en programmes multidisciplinaires : arbres fruitiers, petits fruits, légumes, fines herbes et oléagineux. Les disciplines scientifiques représentées à la Station sont : l'entomologie, l'acarologie, la phytopathologie, la nématologie, la chimie des pesticides, la toxicologie, le génie génétique, la fertilité, le génie aéronautique et la mécanique. La Ferme expérimentale de l'Assomption est reliée administrativement à la Station et poursuit des travaux sur l'amélioration, sur la sélection de cultivars et la gestion de la culture du tabac et de la rose, sur la gestion des plantes ornementales et aussi sur la gestion de plantes de remplacement du tabac.

Ce rapport résume quelques-unes des réalisations de la Station en 1987 dont on trouvera les expériences plus détaillées dans les articles publiés durant l'année. Pour plus d'informations, veuillez vous adresser à : Station de recherches, Direction générale de la recherche, Agriculture Canada, C.P. 457, Saint-Jean-sur-Richelieu, Québec J3B 6Z8; Tél. (514) 346-4494.

C.B. Aubé
Directeur

CULTURES FRUITIÈRES

Nouvelles pratiques culturales pour la production de la fraise. L'utilisation des paillis plastiques de différentes couleurs et des bâches a eu des effets négligeables sur la productivité et la période de fructification des cultivars Tristar à production continue. Seule la fertilisation azotée via l'urée enrobée a apporté des augmentations de rendements appréciables par rapport à la fertilisation au nitrate d'ammoniaque et ce, seulement en sols légers. Les fruits ont été récoltés durant les mois d'août et septembre.

Les plantations différées de gros plants de fraisier dans le but d'obtenir une production programmée 10 semaines après la plantation n'ont pas donné les résultats escomptés. Seulement la plantation du début juin a donné suffisamment de fruits de qualité pour être considérée comme intéressante. La chaleur intense de juillet a été en grande partie responsable d'un manque de fertilisation des fleurs.

CULTURES MARAÎCHÈRES

Design, construction et efficacité d'un appareil de dosage et de mélange de pesticides. L'appareil de dosage et de mélange a été assemblé sur un pulvérisateur au printemps 1987. Cette année, nous avons fait toutes les pulvérisations d'herbicides avec ce pulvérisateur modifié. Le nouvel appareil permet à un seul opérateur d'effectuer plus rapidement un travail qui nécessitait avant deux opérateurs avec l'ancien appareil.

Nous avons effectué des mesures de temps d'exécution avec le nouvel appareil. Il faut en moyenne 3 min pour arroser une parcelle expérimentale et 5,4 min pour arroser quatre parcelles avec le même mélange soit 1,35 min par parcelle. Ces résultats incluent les temps de mélange, d'arrosage et de déplacement entre les parcelles. Nous avons effectué des essais de rinçage avec une suspension et une poudre d'atrazine pour les deux pulvérisateurs. Le nouvel appareil effectue un meilleur rinçage lorsque que nous utilisons la suspension mais un moins bon rinçage lorsque nous utilisons la poudre.

Influence de la composition de la solution de «fertigation» sur le céleri cultivé en multicellules. La préparation de transplants de céleri en plateaux multicellulaires est une opération délicate dont les modalités ont des répercussions jusqu'à la récolte. En serre, les problèmes de croissance liés à la nutrition sont plus susceptibles de se présenter avec les très jeunes plants qui sont davantage sensibles que les plus âgés aux différents engrais. Les transplants de céleri absorbent de préférence l'azote sous forme de NH_4 ce qui a pour effet d'acidifier le pH du milieu racinaire. Pour assurer des conditions nutritives appropriées pendant la période passée en serre, un ratio NO_3-N: NH_4-N de 2:1 est approprié dans la solution de «fertigation». Au delà de ce ratio, le pourcentage de matière sèche dans la partie aérienne diminue, rendant les plants fragiles et cassants.

L'utilisation d'une solution à forte teneur azotée pendant la production de transplants est préférable pour maximiser les rendements vendables. De plus, la présence d'urée dans la solution de «fertigation» à raison de 50 % de la dose d'azote s'avère bénéfique mais seulement à condition que la dose utilisée soit de l'ordre de 350 ppm N. En effet, les rendements vendables sont alors augmentés de 7 % grâce à la présence d'une tige vendable supplémentaire.

Construction d'une carte génétique détaillée de Brassica oleracea au moyen des ADN marqueurs. L'analyse génétique des caractères agronomiques importants (gène de résistance, facteurs de rendements, etc.) nécessite la disponibilité d'une carte génétique détaillée. Présentement, le moyen le plus rapide d'obtenir une carte génétique d'une espèce est d'utiliser des ADN marqueurs. L'obtention de marqueurs distribués à travers le génome de *Brassica oleracea* permettra la localisation rapide de gènes importants comme la résistance à la hernie des crucifères. De tels marqueurs permettront l'identification de plants résistants dans les populations issues du croisement entre variétés résistantes et sensibles. Ces marqueurs ADN liés à des gènes de résistance seront un outil de sélection très utile aux améliorateurs génétiques.

Des lignées de *B. oleracea* ont été croisées pour faire l'analyse génétique de la ségrégation de certains caractères. Une des lignées parentales de *B. oleracea* est une dihaploïde résistante à la race 2 de la hernie des crucifères. Cette lignée a été développée par M. Chiang de notre station de recherches. La position chromosomale d'autres caractères génétiques sera aussi déterminée. Une librairie de clones représentant certaines séquences codantes de *Brassica* a été obtenue. La détection de polymorphismes entre les lignées parentales de *Brassica oleracea* débutera en mai 1988. Avec ce projet, nous pourrons obtenir la première carte génétique détaillée de cette espèce.

Identification des cultivars d'ail au moyen des ADN marqueurs. Parce que l'ail est une espèce stérile, il est très difficile de connaître l'étendue de la variation génétique de cette espèce. De plus, la base génétique de la différence entre les cultivars existants est inconnue. Le présent projet a pour but de permettre d'identifier de façon infaillible chacun des cultivars d'ail au moyen d'ADN marqueurs. Cette étude permettra aussi de mesurer la variation génétique de cette espèce.

Nous avons cloné des séquences d'ADN provenant des chromosomes de l'ail et nous avons analysé plusieurs centaines de clones. Ils seront utilisés comme sonde ADN pour détecter les variations génétiques entre 120 lignées différentes d'ail. Ces lignées d'ail proviennent des centres de ressources génétiques internationales et représentent une grande partie de la variation génétique de l'espèce. Nous avons isolé l'ADN de ces 120 lignées et la détection de polymorphismes débutera en mars 1988.

CULTURES OLÉO-PROTÉIQUES

Évaluation de cultivars

Essais de cultivars de soja. L'évaluation de cultivars de soja pour le Québec s'est poursuivie en 1987 avec l'aide des stations coopérantes. Les cultivars Apache et OAC Libra ont été ajoutés à la liste des cultivars recommandés pour 1988. Ce test a contribué à l'enregistrement des cultivars OT-85-1 et OT-85-5 au Comité d'experts des céréales et des oléagineux de l'est (CECOE).

Essais de cultivars de canola. Cette évaluation s'est poursuivie en 1987 sur le canola de printemps et le canola d'hiver avec l'aide des stations coopérantes dans le cadre des tests coopératifs avec l'Ontario. Ces tests ont contribué à l'enregistrement des cultivars de printemps WW 1447, SV2402 et SV2403 ainsi qu'à celui des cultivars de canola d'hiver SV0214 (Crystal), WW-984 et Arabella au CECOE.

Régie et fertilisation

NPK sur le canola d'hiver. L'application de 25 kg/ha d'azote à l'automne a permis une augmentation de 20 % de la survie à l'hiver par rapport au témoin. Une dose de 150 kg/ha d'azote appliquée au printemps à la reprise des plants a augmenté le rendement de 56 % par rapport au témoin mais a retardé la maturité des grains de 3 à 5 jours. Ces résultats ne sont que partiels en raison d'un mauvais drainage de surface qui a détruit 40 % des parcelles.

Étude de rendement maximum sur le soja. Un essai préliminaire n'a révélé aucune réponse aux traitements NPK avec ou sans application de magnésium, de manganèse ou de zinc. L'irrigation n'a eu aucun effet, ni deux densités de population. La coupe du bourgeon terminal au stade «début floraison» a révélé qu'un stress semblable à une défoliation par la grêle peut retarder la maturité d'un cultivar hâtif (Maple Amber). Toutefois, un cultivar plus tardif (Bicentennial) n'a pas été retardé dans sa maturité. Cet essai démontre la facilité d'adaptation du soja dans des conditions de croissance variable.

Diagnostic foliaire (DRIS) sur le soja. L'utilisation du système integré de diagnostic et de recommandation (DRIS) développé sur le soja aux États-Unis semble possible au Québec mais doit être adapté. En effet, le système américain tend à surestimer les déficiences en azote à partir des analyses foliaires. De nouvelles normes pour le Québec sont à l'étude d'après les relevés d'enquête effectués au Québec.

Évaluation d'herbicides sur le soja. Les essais d'herbicides en pré-levée et post-levée sur le soja ainsi que les anti-graminés ont permis d'évaluer les nouveaux herbicides et les mélanges pour les prochaines recommandations au Québec. En 1987, la combinaison en pré-levée Galex (métolachlore/linuron) et métribuzine a le mieux combattu les mauvaises herbes. Les traitements post-levée ont été d'une efficacité équivalente mais le meilleur rendement a été obtenu avec la formulation DPXM 6316 + Agral 90 et DPXY 6202-31 + CanPlus 411.

PLANTES ORNEMENTALES

Propagation de plantes. Deux cultivars de rosiers créés par Agriculture Canada (le Champlain et le John Franklin), deux hybrides de thé (le Landora et le Jean-Paul II) et un cultivar de cerisier, le *Prunus mackii*, ont été propagés avec succès par culture de tissus *in vitro*. On a également identifié le type et la teneur en cytokinine pour leur prolifération, ainsi que la concentration en auxine du milieu de culture pour partir la rhizogénèse. Cette technique peut être utilisée par les pépiniéristes pour produire en très peu de temps des quantités importantes de plantules saines.

TABAC

Fertilisation du tabac à cigare. Nous avons étudié l'effet de diverses sources d'azote et de phosphore pour caractériser leur apport aux caractéristiques agronomiques et chimiques du tabac à cigare. Les résultats ont démontré que l'azote sous forme d'urée et le phosphore sous forme de superphosphate simple sont les meilleurs éléments fertilisants à utiliser pour cette culture.

Physiologie nutritionnelle du tabac. Nous avons établi un lien entre la griselure du tabac et les caractéristiques suivantes : la toxicité du fer, du manganèse et du chlore, et une carence en azote et en potassium. Ces éléments sont requis pour la translocation des électrons par photosynthèse. La perturbation du métabolisme d'un plan normal, causée par une toxicité ou une carence, peut altérer la translocation des éléments selon le mode de l'oxydase des cytochromes en un mode qui induit la peroxydase, donc des polyphénols, des quinones et des composés voisins de la mélanine qui sont à l'origine d'un effet bronzé et grisé sur les feuilles de tabac. Selon l'hypothèse que le mode de translocation des éléments est perturbé chez différents types de tabac grisé, il serait possible de déterminer une cause commune de ce désordre physiologique.

Tache brune du tabac jaune. Le radio isotope (Fe^{55}) et l'élément fer ont été utilisés pour déterminer l'incidence de cet élément sur l'apparition de la tache brune sur des feuilles de tabac grisé cultivé en serre. La grille de répartition de Fe^{55} dans les feuilles a été comparable à celle des taches brunes et la distribution de l'isotope a suivi un parallèle au développement séquentiel des taches observées à la fois sur des plants cultivés en serre et en champ. Des plants en culture hydroponique, à laquelle on a ajouté de 5 à 35 ppm de fer, ont montré que l'indice de tabac grisé dans les feuilles médianes et supérieures était similaire à la grille de répartition du fer dans les feuilles. L'indice le plus élevé de tabac grisé a été observé avec l'apport de fer le plus élevé (335 ppm). Aucun dépôt de fer n'a été retrouvé dans les petites nervures des feuilles grisées. Ces résultats démontrent clairement la relation entre la présence d'un excès du fer et l'apparition de la bigarrure sur les feuilles de tabac grisé.

Au cours d'une expérience comparable à la précédente, des apports de manganèse allant

de 5 à 65 ppm ont été comparés à des taux identiques de fer. Les résultats ont confirmé que seul l'élément Fe est à l'origine de la bigarrure et de la tache brune associées à la manifestation du tabac grisé.

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Research Station, Delhi, Ontario

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M.C. Watson, B.S.A.	Tobacco

Departure

R.S. Pandeya, B.Sc., M.Sc., Ph.D. Transferred to Plant Research Centre 1 April 1987	Genetics and plant breeding

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[1] Seconded from Libraries Division, Corporate Management Branch.

[2] Provided by Ontario Ministry of Agriculture and Food.

INTRODUCTION

The Delhi Research Station has national responsibility for research in support of the flue-cured tobacco industry in Ontario, Quebec, and the Maritime Provinces. Increasing importance is also being assigned to our other major program to find alternative crops for the sandy soils of the tobacco area of Ontario.

This report provides a brief summary of some of the results obtained in 1987. Further information can be obtained from the Research Station, Research Branch, Agriculture Canada, P.O. Box 186, Delhi, Ont. N4B 2W9; Tel. (519) 582-1950.

P.W. Johnson
Director

TOBACCO

Production

Transplants, affected by partial freezing injury, can be decapitated to encourage an axillary bud to assume extension of the main growing axis. This management procedure provided significantly improved crop productivity compared with replanting 2 weeks after normal transplanting.

Genetics and plant breeding

A breeding program was initiated in 1982 to incorporate immunity to black root rot into four current cultivars: Delgold, Candel, Newdel, and Nordel. Testing and selection have been confined to laboratory procedures. From the initial six lines selected for their immunity, crossing, backcrossing, and selection have progressed to the final fourth backcross and two generations of selfing. Of the initial 24 lines, there are currently 154 lines retained for further testing. Fifty-five of these lines expressed total immunity, and seed for the next generation will be harvested and field tested in 1988.

Lines derived from somatic cells from the biotechnology breeding method advanced in 1987. One hundred lines were under intensive field investigation for yield, quality, chemistry, and physical qualities compared with check cultivars. Of these, 10 lines will be advanced to the advanced strain test. Fifteen somatic lines were in the advanced strain test in 1987. Nine of these lines will be continued in 1988. Of eight somatic lines in the cultivar registration test, five will be tested again in 1988, with four of these undergoing regional farm testing.

In 1987 Delhi-bred cultivars were grown on 99% of the Ontario hectarage. Delgold was grown on 86% of the farms; Candel on 6%; Delliot (registered 1986) on 5%; and Delhi 76, Newdel, and Nordel collectively on 2%.

Chemistry

Shatter resistance of cured tobacco leaf is an important measure of its physical quality. Multilinear regression analysis identified reducing sugars, potassium, uronic acids, malic acid, calcium, iron, and chlorides as having significant associations, which accounted for 95% of the variance with measured shatter resistance. Reducing sugars and potassium were the two major chemical constituents of tobacco leaf and contributed approximately 90% to the variance of estimating shatter resistance.

A xylan of approximately 70% purity was isolated from cured leaves of bright tobacco (*Nicotiana tabacum* L. 'Delhi 76') by sodium hydroxide extraction and subsequent fractionation on diethylaminoethylcellulose (DEAE). Acid hydrolysis produced arabinose, galactose, glucose, mannose, and xylose in molar proportions of 1:1.3:3.8:0.2:17.3, and showed that the xylan was composed of a linear chain of β-(1-4)-linked D-xylopyranosyl units.

A rapid quantitative method was developed for the analysis of solanesol (a major source of polynuclear aromatic hydrocarbons in tobacco smoke) in flue-cured tobacco (*Nicotiana tabacum* L.). Tobacco samples were extracted with aqueous methanol and fractionated on a SEP-PAK C_{18} cartridge. Solanesol was eluted from the cartridge with acetone. Separation by nonaqueous high-performance reversed-phase liquid chromatography was achieved by gradient elution employing methanol and acetonitrile. The method was reproducible with a relative standard deviation of less than 5%. There was a good agreement between the results obtained by the liquid chromatographic procedure and a gas chromatographic determination.

A study was completed of the chemical composition of representative commercial grades of Ontario flue-cured tobacco selected at random from the three auction exchanges from the 1978 tobacco crop. Comparisons were made with the grade price using the stalk position, color, and quality classification of each grade. Total alkaloids, reducing sugars, neophytadiene, aqueous methanol extracts, nonvolatile organic acids, phenolic constituents, fatty acids, and mineral constituents were determined on individual grade samples. In general, the largest chemical differences were found when comparisons were made on the basis of the stalk position aspect of the grade classification; however, chemical differences resulting from the color classification of grades were also often quite large. Except for the mahogany grades, differences among the quality classification of each grade were usually smaller than differences resulting from stalk position or color.

Protection

Severe outbreaks of the green peach aphid, *Myzus persicae* (Sulzer) (90% red biotype and 10% green biotype), occurred on tobacco throughout the tobacco-growing areas of Ontario from mid July to early September in 1987. The population density ranged from 639 to 2864, with an average of 1452 aphids per leaf. Control measures were employed by all growers, and some fields were sprayed two or three times.

A 2-year greenhouse and field study on the residual activity of acephate, azinphos-methyl, methomyl, oxydemeton-methyl, and pirimicarb against aphids on tobacco showed that all insecticides were highly toxic to the aphids immediately after treatment. Acephate and oxydemeton-methyl proved to be the best and most persistent aphicides, followed by pirimicarb, azinphos-methyl, and methomyl, in that order.

Two insect growth regulators, triflumuron and teflubenzuron, were evaluated on treated tobacco leaves in the laboratory against third- and fifth-instar larvae of the darksided cutworm, *Euxoa messoria* (Harris). Data indicated that both materials, regardless of the rates used, caused low larval mortality 2 weeks after treatment. A high percentage of the larvae failed to pupate and eventually died. A small number of adults emerged from pupae. The third-instar larvae were more susceptible than the fifth-instar larvae. Some feeding inhibition was also observed.

Annual surveys of pesticide applications and terminal residues on 32–34 Ontario farms producing flue-cured tobacco were continued between 1980 and 1985. Applications of synthetic pyrethroids increased for cutworm control, and chlorpyrifos applications decreased. Acephate was most widely used for foliar insects followed by *Bacillus thuringiensis* Berliner and oxydemeton-methyl. Metalaxyl was widely applied following the outbreak of blue mold (*Peronospora tabacina* Adam) in 1979 but became insignificant by 1983. Synthetic pyrethroid residues were absent from cured leaf where the label recommendations were followed, but residues were found where topical applications were made in mid season. Metalaxyl and diphenamid residues appeared in cured leaf where they were used for disease and weed control, respectively. Diphenamid residues were present predominantly as the *N*-methyl metabolite. Minor residues of several organochlorine insecticides were found in both soil and cured leaf 5–15 years after their use was terminated. Organophosphorus insecticide residues were absent or at trace levels in soils and cured leaf. Acephate residues were rarely found, but methamidophos residues were present. These residues were found in cured leaf at all stalk positions but mainly in sand leaves.

In flue-cured tobacco, fluazifop-butyl has been registered for postemergent control of weeds and annual grasses, and napropamide has been registered for preemergence control of broadleaved weeds and annual grasses. These herbicides will be used by the growers in 1988.

ALTERNATIVE CROPS

Field crops

Two new peanut cultivars were supported for interim registration. These cultivars were developed by the University of Guelph and field tested in conjunction with the Delhi Research Station. Line PO7082 (546 × chico), with flesh-colored skin, has significantly larger seed and increased yield over OAC Garroy. Line P89984, a wine-colored seed variety

(355283 × chico), has the same seed size as OAC Garroy but is superior in yield. These lines should be available for commercial production in 2–3 years.

Heavy infestations of the two-spotted spider mite, *Tetranychus urticae* Koch, on peanuts in August in 1987 were widespread throughout all peanut-growing areas. This is the first economic outbreak of the two-spotted spider mite on peanuts.

Six insecticides (acephate, carbaryl, cypermethrin, fenvalerate, permethrin, and methidathion) were evaluated as foliar sprays on peanuts against the potato leafhopper, *Empoasca fabae* (Harris). All insecticides significantly suppressed leafhopper populations in the field. Results obtained were consistent over 3 years. Acephate was superior to carbaryl against potato leafhoppers from the standpoint of residual toxicity. Sampling data demonstrated that monitoring of nymphs can be used successfully to schedule insecticidal sprays for control of this pest on commercially grown peanuts.

Preliminary test plot production of kenaf was 8.0 t/ha of dry matter. These results have precipitated interest from the Quebec and Ontario Paper Company of Thorold, Ont. This company has indicated they would like to establish a limited commercial hectarage in 1988.

Tarnished plant bugs, *Lygus* spp., were numerous in evening-primrose plots during the growing season in 1987. They caused noticeable injuries, not only by direct feeding on the young leaves and buds but also by depositing individual eggs in the young seed pods. Over 50% of the seed pods were found to bear tarnished plant bug eggs.

Approximately 800 ha of white beans were produced on sandy land in 1987. Severe, dry weather delayed pod set, and August rains produced excessive regrowth. A fall frost on 3 October damaged most of the white beans, and they were ploughed down. In plots at Delhi, most treatments had 30–40% frozen seed and would not be acceptable to the trade.

Preliminary meetings to establish a commercial peppermint hectarage in Ontario have taken place. Test plots at the research station were distilled by Coniferious Oil Ltd., and the oil produced was of good quality.

Horticultural crops

Bare-rooted tomato seedlings produced in muck seedbeds at densities of 800–1400 seeds per square metre were found to produce crops of equal yield and quality when compared with crops produced by bare-rooted seedlings imported from Georgia or with intact root seedlings produced by two popular plug plant systems. Muck seedbed grown seedlings matured 5–7 days earlier than did seedlings grown by other means.

The 1987 growing season was exceptionally dry during July; consequently, the effect of irrigation on the yield of paste tomatoes was greater than previously observed. Three irrigations in July (8, 21, and 27 July) resulted in an average yield of 84.9 t/ha compared with 36.9 t/ha for the nonirrigated check.

Six sweet potato cultivars were evaluated to determine their yield potential on former tobacco soils. Yields ranged from 10.6 t/ha to 30.6 t/ha of U.S. No. 1 size table-stock roots.

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Research Station, Harrow, Ontario

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A.H. Teich, B.A., B.S.A., M.Sc., Ph.D.	Winter wheat breeding
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Departure

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EXTENSION SERVICES[8]

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[1] Seconded from Libraries Division, Corporate Management Branch.

[2] Seconded to the Soil and Water Environmental Enhancement Program.

[3] Transferred from Research Station, Lethbridge, Alta., on 5 January 1987.

[4] On educational leave, Michigan State University, September 1986–.

[5] On educational leave, Ohio State University, September 1986–.

[6] Transferred from Research Station, Lethbridge, Alta., on 24 August 1987.

[7] On postdoctoral transfer of work, Center for Irrigation and Fresh Water Research, Griffith, Australia, and Division of Plant Industry, Commonwealth Scientific and Industrial Research Organization, Canberra, Australia, from 23 May 1987 to 30 May 1988.

[8] Provided by Ontario Ministry of Agriculture and Food.

INTRODUCTION

The Research Station at Harrow serves southwestern Ontario, where favorable soils and climatic conditions permit an intensive and diversified agriculture. The station has 30 researchers working in interdisciplinary research in commodity-oriented programs designed to improve yield, quality, and efficiency of crop production. Crops under study include field and greenhouse vegetables, stone fruits, pome fruits, corn, soybeans, field beans, and winter wheat. Areas of emphasis for applied and basic research relating to the above crops are as follows: crop improvement using breeding and genetics to create new germ plasm and cultivars with improved agronomic or horticultural characteristics, improved resistance to pests, and increased suitability to environmental conditions; crop protection using chemical, biological, and cultural methods to control diseases, insects, and weeds, with emphasis on the management of pest populations, development of integrated crop management systems, and improvement of environmental quality; and crop and soil management using improved cultural practices, cropping systems, fertilizer practices, and tillage systems to improve soil structure and fertility, to reduce soil erosion, and to improve water quality.

The report provides brief summaries of results obtained in 1987. Further information can be obtained by writing to the Research Station, Agriculture Canada, Harrow, Ont. N0R 1G0; Tel. (519)738-2251.

C.F. Marks
Director

FIELD CROPS

Corn

Breeding. CH807-44, an inbred that requires about 1600 heat units from planting to tasseling and silking, was released to the industry through the Industrial Relations Office. It has potential for combining with other inbreds to produce commercial hybrids with high yield and good standability.

Compaction and surface structure of a poorly drained soil. The surface structure of the poorly drained soils of southwestern Ontario has deteriorated to a level that is considered to limit corn and soybean productivity. The contribution of vehicle compaction to surface soil structural deterioration on these soils has not been shown. Fall vehicle compaction of the surface soil (at soil moisture content suitable for tillage) did not significantly contribute to soil structural deterioration and did not limit the productivity of corn and soybean grown in a corn–soybean–corn rotation. However, fall compaction did significantly restrict early to mid-season plant development.

Spring compaction generally contributed to soil structure deterioration and limited productivity. There were no cumulative detrimental effects of fall or spring compaction on soil structure, plant development, or yield.

Effect of cropping system on soil structure. The upper horizon of long-term corn plots on a Brookston clay loam soil differed markedly from those of a bluegrass plot and a never-cultivated plot by having 6% or fewer macrospores compared with 10%, and isolated pores compared with interconnected pores in the latter. The bulk density of the corn plots was higher than other plots evaluated, indicating less porosity and more soil per unit area. The plots with oat–alfalfa–alfalfa–corn rotation contained many more biospores larger than 0.5 mm in diameter than did the continuous corn plots. Below a depth of 30 cm the soil in all plots had a similar structure. Continuous cropping with corn tended to reduce soil porosity and the number of interconnected pores in the upper soil profile, thus retarding water infiltration and resulting in conditions that impeded emergence of seedlings.

Soybeans

Agronomy. Three commonly used soybean herbicides (metribuzin, trifluralin, and metolachlor) were applied to three soybean cultivars grown under stressed and nonstressed conditions on a Brookston clay soil in 1985, 1986, and 1987. Under stressed conditions, i.e., continuous soybeans with minimum tillage to favor *Phytophthora* rot caused by *Pmg*, the yields of the *Pmg*-resistant Corsoy 79 cultivar and the *Pmg*-tolerant Elgin cultivar were not affected. However, the yield of the moderately susceptible Jewel cultivar was significantly reduced (15%) by metolachlor. In a nonstress situation of soybeans in a rotation with conventional tillage, there were no effects of herbicide treatments versus hand weeding for Corsoy 79, Elgin, and Jewel.

Breeding and genetics. Haroson, a backcross-derived cultivar, was released to seed growers through the SeCan Association. It is very similar to Hodgson except for resistance to *Phytophthora* root rot, which occurs on heavy clay soils of southwestern Ontario. Haroson is resistant to races 1-3, 6-11, 13, 15, 17, 21, 23, and 24 of *Phytophthora megasperma* var. *glycinea* (*Pmg*), whereas Hodgson is susceptible to all races.

Several of the *Rps* genes for resistance to *Pmg* have been backcrossed into the Harosoy cultivar to develop isolines. Seed is available for research purposes.

Effects of hormone herbicide drift on soybeans. Drift of 2,4-D, dicamba, and mixtures of these herbicides on soybeans during application to corn fields has been a concern for many years. These materials with active ingredient (a.i.) at rates of 0.1 kg/ha down to 0.0005 kg/ha directly applied to soybeans at the third trifoliate leaf stage determined that the high rate for 2,4-D caused wilting of the plants, but recovery occurred and yields were only slightly reduced; for dicamba almost total loss of the crop occurred. Injury from 2,4-D was only temporary at all other rates, and no yield reduction occurred below an application rate with a.i. at 0.01 kg/ha. Dicamba caused cosmetic injury from the 0.0005 kg rate, and this did not show up for 2–3 weeks after application; yield was not significantly reduced from rates of a.i. below 0.001 kg/ha. Chemical analysis of the various treatments determined that only the high rates could be detected up to 15 days after application. Soybeans drilled in 15-cm rows suffered five times more injury than those in 60-cm rows, presumably because of the greater leaf area exposed. Drift injury from hormone-type herbicides is primarily from the physical movement of droplets rather than through vaporization. Chemical analysis is not a useful technique for determining injury levels; a comparison of yields from the injured area and an uninjured area is the suggested method of determining yield reduction.

Phytophthora root rot. A 2-year experiment in which 10 backcross-derived cultivars with a dominant gene (*Rps1Rps1*) for resistance to root rot and their recurrent cultivars with a recessive gene (*rps1rps1*) were assessed in the presence of compatible races of root rot in the field showed that single "defeated" genes do not contribute to disease tolerance of root rot. New genes are required to control new races of the root rot organism.

Field beans

Breeding and genetics. Centralia, a white bean, short-vine cultivar (Registration No. 2845), was released. It is an ExRico 23 type, medium to early maturing, with high yield capability. It has *Are* resistance to all prevailing races of bean anthracnose (*Colletotrichum lindemuthianum*) and resistance to bean common mosaic virus. In the Ontario field bean variety trials in 1985–1987, Centralia was 3 and 9 days earlier than Harokent and ExRico 23, respectively. It averaged 13% more yield than Harokent and 5% lower yield than ExRico 23.

Forty-five F_2 and F_3 populations of 9 × 9 partial diallel crosses grown at two locations were analyzed using Griffing's diallel method 2. A major contribution to genotypic variance was the variance of general combining ability for dates of blossom and maturity, 100 seed weight, and seed yield. Thus, these characteristics were controlled mainly by additive gene effects, which suggests that they could be fixed in pure-line selections. Low heritability (h^2) for yield indicates the difficulty of selecting high yielding progenies and requires large populations.

Two white bean cultivars, OAC Rico (Rico) and Swan Valley (SV), were treated with 0.4 M EMS (ethylmethane sulfonate). The material was screened for nitrate-tolerant supernodulating (ntsn) mutants. One ntsn mutant from 175 Rico M_2 families and two ntsn mutants from 467 SV M_2 families were obtained. The ntsn mutants were profusely nodulated in the presence of 8 mM nitrate plus 2 mM ammonium, which strongly inhibited nodulation of the parental cultivars. M_3 progenies derived from the ntsn mutants bred true. Genetic control of the ntsn was determined by examining nodulation of F_1 and F_2 plants from crosses between the ntsn and wild type parents, and between two different ntsn mutants obtained from the Rico and SV populations in the presence of 10 m*M* of combined-N. The ntsn character was inherited as a single recessive gene, and the ntsn mutants of the two different source populations were under the control of the same gene.

Halo blight. Among 16 bean cultivars tested in the growth chamber against race 2 of *Pseudomonas syringae* pv. *phaseoli*, G.N. Nebr. No. 1, selection 27 was resistant; OAC Rico, OAC Seaforth, OAC 85-2, and Harofleet were less susceptible. Against race 1 of the pathogen, G.N. Nebr. No. 1, selection 27, OAC Rico, an OAC Seaforth were among those less susceptible. In field evaluation against race 2, G.N. Nebr. No. 1, selection 27 were resistant, and OAC Rico, Stinger, and Crestwood were less susceptible.

Root rot. Soil compaction significantly increased root rot severity by 15% and decreased photosynthetic rate by 36%. It also reduced nodulation and nodule efficiency as reflected in the reduced nitrogenase activity and leghemaglobin content of nodules. At soil bulk densities of 1.2, 1.4, and 1.6 g/cm^3, the reduction in growth was 46, 39, and 71%, respectively.

White mold. Of the 12 lines of *Phaseolus vulgaris* resistant to white mold that were tested in a field with heavy white mold infestation, the cultivars and lines that showed a high degree of tolerance were as follows: M0162, XPB-155, Laureat, PI165787, ExRico 23, A55, 8BP-266, N.Y.-2558, and Rabia de Gato. These are gene sources for breeding commercial beans tolerant of white mold.

Wheat

Control of fusarium scab. Research at Harrow and a study of published research results have been integrated to produce a guideline for partial control of scab. This guideline includes use of resistant cultivars, soil tillage, control of graminaceous weeds and crop rotation to reduce the amount of inoculum, control of nongraminaceous weeds to reduce humidity in the crop, use of urea as a nitrogen fertilizer source, use of no more than the optimum amount of nitrogen, and storage of the wheat crop at less than 18% moisture. Use of this guideline reduces scab severity and deoxynivalenol accumulation in a wheat crop, thereby increasing yield, profitability, and marketability of the crop.

FIELD VEGETABLES

Green peas

Root rot. An integrated disease control system was developed that includes planting resistant cultivars, using new seed treatments that avoid MCPA/MCPB, reducing soil compaction, practicing fall chisel plowing or fall plowing with a raised spring seedbed, using soil disease indexing, and planting green manure crops in the intervals between pea crops. Pea yield per hectare in 1983 averaged 1420 kg in Essex and Kent counties because of a severe root rot problem; the integrated disease control system now results in 3370 kg/ha.

Potatoes

Microbial control of potato beetle. Application of formulations of thuringiensis, the B-exotoxin of *Bacillus thuringiensis* (Bt) and formulations of Bt var. *san diego* (Btsd) reduced populations of larvae of the Colorado potato beetle on potatoes and resulted in yields similar to yields by plots treated with carbofuran. Treatment of tomatoes with Btsd reduced larvae populations of the Colorado potato beetle, compared with the nontreated check, and increased yields of nondamaged fruit. An initial application of carbofuran followed by applications of thuringiensis or Btsd protected potatoes or tomatoes as well as did carbofuran used alone in a treatment program, indicating a method for reduction of amount of chemical pesticide applied without sacrificing quality or quantity of crop yield.

Tomatoes

Bacterial canker. In the greenhouse more than 80% of seeds in intact tomato fruits were infected by inoculating the peduncle with *Clavibacter michiganensis* ssp. *michiganensis*. These seeds were used in studies on seed treatments for disinfection and field performance of transplants. Seeds soaked in hydrochloric acid (pH 1.0) for 1 min and dried overnight were rid of canker bacteria with or without prior extraction by fermentation for 48 h. In further studies, 1 h of acid treatment, followed by rinsing in water, disinfected the seeds without adverse effects on germination. Disinfection of acid-treated seeds was confirmed by rinsing in buffer until the seed pH was raised to neutral and then plating on selective media. Disinfection by extracting seed by fermentation at 20, 25, and 30°C up to 120 h was unreliable. Infected seeds germinated as well as uninfected seeds and produced apparently normal transplants. Infected seeds treated with acid produced plants relatively free from canker in the field and with higher plant weight and yield than those produced from infected but untreated seeds; the latter had a high percentage of infected seeds in their fruits, whereas plants raised from acid-treated seeds had few infected seeds. A complete disease cycle was thus established, starting from infected seed through transplant to the production of a new crop of infected seeds, which provided a new primary source of infection.

Ice nucleation and leaf spotting. Pseudomonas syringae pv. *syringae* van Hall, which causes leaf-spotting similar to bacterial speck on Georgian tomato transplants and ice nucleation in plants when temperatures fall slightly below freezing, survived on transplants shipped north in the spring. The bacterium was responsible for increasing plant loss from 34 to 70% when temperatures dipped below freezing. The organism survived as long as 1 month on tomato foliage in the field without expressing disease symptoms.

Integrated crop management. Yield and damage by pests of processing tomatoes in plots planted in 1986 and treated in 1987 with pesticides by a preestablished schedule were compared with yield and damage in plots planted previously to alfalfa or white clover and oats treated in 1987 with pesticides according to action thresholds and environmental conditions. Plots were replicated in three different fields. Fungicides and insecticides were applied five and six times, respectively, to the plots treated by the scheduled regime. Three applications of fungicides and four or five applications (depending on the replicate) of insecticides were applied to the plots according to monitoring of pest occurrence and environmental conditions. Yield and quality of fruit did not differ substantially. The data suggest that infestations of diseases and insects, particularly the Colorado potato beetle, are favored by repeated cropping to tomatoes. This was the 3rd year of a multidisciplinary study on the management of this crop.

Temporary storage of high-density, multicelled tray processing tomato seedlings. An experiment was conducted to determine the most effective method of storing trays of high-density tomato seedlings. Six-week-old seedlings were stored in the greenhouse, outdoors, or in a barn, the doors of which were opened during the day. The condition of the plants from all treatments was surprisingly good even after 4–6 weeks. After 3 weeks of storage (10 June field setting) there was no difference in early yield, regardless of whether they were stored in the greenhouse, the barn, or outdoors. Avoiding storage of seedlings outdoors in wet weather is recommended to prevent damage from *Sclerotinia* white rot. Survival of the seedlings in the field after transplanting was reduced only if root growth of the seedlings was allowed to occur through the drainage holes of the cells, as when the flats were placed on the ground. Dry weights of the seedlings were 0.3, 0.8, and 1.7 g on 10 June, respectively, for storage in the barn, the greenhouse, and outdoors; by 23 July there was no weight difference among the plants. It appears that tray seedlings can be easily stored for 3 weeks without any adverse effects.

Lycopersicon peruvianum. Because of severe incongruity barriers, the extensive genetic variability of *L. peruvianum* has been largely inaccessible for tomato improvement. Using the embryo callus technique, 65 crosses involving 11 *L. peruvianum* accessions were made in 1987. For these crosses, two groups of populations were far more responsive than others: crosses with LA 1708 or PI 365968 as the peruvianum parent and those with a clearly esculentum-like population derived from the cross H-2653/Pur-812/LA-1708 as the esculentum parent. To facilitate access to other peruvianum accessions, 42 successful crosses were made between peruvianum crosses and crosses with LA-1708. If these prove to be fully compatible with esculentum, efforts will be made to access a much wider range of peruvianum material.

Metribuzin resistance. For metribuzin resistance, populations derived from University of Georgia releases 1113MT and 1160MT and from Vision were screened in the greenhouse with a.i. at rates of 4 kg/ha. All the checks and the Vision-derived plants were killed, and approximately one-quarter of the plants in the 1113MT and 1160MT populations remained healthy, confirming the reported single gene recessive control of this trait. Early, large-fruited selections were backcrossed in the field to adapted cultivars to permit generation advance in the winter and screening next spring.

Somaclonal variability. An evaluation of nearly 2000 R-2, calli-derived tomato plants for somaclonal variability resulted in 13% tetraploids, 2% male steriles, and 8% mutant phenotypes. These mutants fell into 11 different categories, including dwarf plant type, shortened internodes, lack of apical dominance, high branching, and nonripening. An additional 12% varied from the check in a quantitative trait (maturity, plant morphology, fruit size, fruit load, disease response). Although the majority of the identified variant lines were not desirable for breeding purposes, several potentially beneficial lines were identified and will be further evaluated. These include some lines with earliness, larger fruit yield, suppressed apical dominance and slow ripening. The latter phenotype had very high Libby's Viscosity values (41.0 s versus 29.3 s for Pur-812) combined with a moderate reduction in the Hunter's a/b ratio (1.815 versus 2.156 for Pur-812). Up to three clearly different variant types were found in some lines.

GREENHOUSE VEGETABLES

Cucumbers

Biological control of powdery mildew. Two yeastlike epiphytic fungi killed conidia and mycelium of *Sphaerotheca fuliginea* on cucumber leaves in a few hours in a relative humidity of more than 95% and at an optimum temperature of 26°C. The antagonists are disposed as *Stephanoascus rugulosa* sp. nov. (anamorph *Sporothrix rugulosus* sp. nov.) and *Stephanoascus flocculosus* sp. nov. (anamorph *Sporothrix flocculosa* sp. nov.). *Tilletiopsis* spp. also control powdery mildew in a similar way.

Cucumber stem rot. A new and serious stem rot of cucumbers was shown to be caused by *Penicillium crustosum*, which, on inoculation, also caused a rot of cucumber fruit and apples. In vitro, the pathogen was inhibited by benomyl and vinclozolin.

Cultural control of powdery mildew. It had been shown previously that water sprays control powdery mildew; the yeastlike epiphytes also require high levels of humidity. The humidity is readily supplied by a fogging system that also controls temperatures to below the optimum for powdery mildew. Very considerable reduction in powdery mildew is also achieved by raising transplants well away from infested main crops.

Fruit thinning. Cucumber crops are characterized by an initial period of heavy fruit production while the main stem fruit is harvested, which establishes a 3-week cycle of high and low productivity. The resulting oscillation in productivity creates problems in marketing and greenhouse labor management. Main-stem fruit thinning was evaluated as a potentially effective tool for balancing vegetative growth with fruit growth. Main-stem fruit load (100%, 75%, and 50% of natural load) had significant effects on early marketable yield. Specifically, plants with 100% fruit load had the highest early marketable yield but also had the lowest percentage of large and medium size fruit as well as the highest percentage of small fruit. These effects of the main-stem fruit load treatments on marketable yield were not evident at the end of the season. Furthermore, an economic analysis of the early yield results indicated that the increased productivity with 100% main-stem fruit load compensated for the associated loss of revenue because of poorer fruit quality. In light of these findings and in consideration of the extra labor required for main-stem fruit thinning, this practice is not recommended to commercial growers.

Scanning electron microscopy. A new technique of growing fungi on human hair was evolved for the better taxonomic evaluation of the delicate conidial chains of *Sporothrix* spp.

Tomatoes

Bacterial stem rot. Under nutrient film technique as well as in bag culture, stem rot induced by *Erwinia carotovora* ssp. *carotovora* in tomato cultivar CR-6 was retarded by a higher potassium-to-nitrogen ratio (4:1) in fertilizer application than the normal 2:1 ratio or a lower one of 1:1. Therefore, growers with a history of the disease can adjust fertilizer rates to prevent occurrence of the disease.

Biological control of Fusarium crown and root rot. A number of fungi and streptomyces have been isolated that show considerable antagonism to *Fusarium oxysporum* f. sp. *radicis-lycopersici* in vitro and in seedling pathogenicity tests.

Gaseous carbon dioxide injection into the irrigation water for pH control. The precipitation of various Ca-containing salts and the resulting clogging of the drip-irrigation emiters are usually minimized by controlling the pH of the fertilizer solution to about 5.5 with the addition of acids (e.g., H_3PO_4, HNO_3, H_2SO_4). Although this technique is effective in keeping the irrigation lines clean, it is also expensive, dangerous to the operator, and incompatible with occasional needs to maintain low N, or P, or SO_4 levels in the fertilizer solution. As an alternative to injecting acid, a simple technique was developed for the injection of CO_2 into the irrigation line, which was tested over two cropping seasons with favorable results. The new technique is based on the principle that a certain amount of CO_2 (depending on temperature and pressure) is capable of reacting with H_2O, with the end result the formation of H_2CO_3. Under normal operating conditions, enough H_2CO_3 is formed to reduce the pH of the fertilizer solution from a usual 7.5 to at least 5.8. Overdosing of CO_2 and dangerously low pH of the fertilizer solution, as could be the case with an accidental overdose of acids, is not a concern since the amount of CO_2 in solution depends on the pressure of its injection, which is limited by the operating pressure of the irrigation system. Sections of the irrigation line were sliced open at the end of the test period, and no visible difference could be detected between the acid and CO_2 techniques with regard to the amount of salt deposited. Furthermore, there was no significant yield variation resulting from the method used for pH control of the fertilizer solution.

Nutrition of drip-irrigated crops. Five cultivars were planted in groundbeds and irrigated equally through three separate drip-irrigation systems. High (14:1), medium (8:1), and low (2:1) K-to-N fertilizer schedules were initiated at the onset of a spring crop, and all converged gradually to a common K-to-N schedule (2:1) over a 3-month period. All plants received a common K-to-N schedule for the remainder of the season. The early and final marketable yields were not affected significantly by these nutritional treatments. As a result, the high K-to-N schedules commonly used by commercial growers are now being discouraged as an unnecessary waste of K fertilizer and a potential cause of cation imbalance in the growth medium.

TREE FRUITS

Apricot

Breeding. Thirteen different hybrid combinations were made, of which 12 were elite × elite crosses and one was an elite × Early Samarkand (a very early season plant introduction from the USSR). Eight new fresh-market selections were made and propagated for further trials. Three advanced selections (HW447, HW448, HW449) will be placed in regional trials in 1988. These three selections have adequate levels of coldhardiness and disease resistance combined with adequate productivity, fruit appearance, and quality to merit testing for regional adaptation in southern Ontario, southern British Columbia, and other regions where apricots are grown successfully.

Controlled freezing studies were carried out on fully acclimated dormant shoots of nine hybrid seedling selections and four commercial standards. Three selections exceeded the flower-bud hardiness of Goldcot, the hardy standard, and four selections exceeded Goldcot in xylem hardiness. Only one selection (H8207001) was more bud and wood hardy than Goldcot.

Peach

Breeding. Thirty-one parental combinations were made of peach × peach, peach × nectarine and nectarine × nectarine. Nine peach and two nectarine selections from crosses made previously were propagated for entry in regional trials in 1989. Four advanced peach selections (HW256, HW257, HW258, HW259) and one nectarine (HW106) will be placed in regional trials for the first time in 1988. These advanced selections have levels of coldhardiness and disease resistance, combined with desirable productivity, fruit appearance, and quality, to merit testing for regional adaptation and commercial potential in southern Ontario, southern British Columbia, and other regions where Redhaven peach is grown successfully.

Integrated orchard management. Three cultivars (Garnet Beauty, Harbrite, Canadian Harmony); two ground covers (temporary cover, permanent sod); and two irrigation treatments (trickle, none) were studied in an experimental peach orchard on Fox sand established in 1980. The growing season in 1987 was unusually hot and dry. Cultivars differed significantly in terms of total and marketable yields, Canadian Harmony being the highest yielding. The ground cover and irrigation treatments did not significantly influence yields, and there were no treatment interactions. Bloom intensity was significantly affected by cultivar, ground cover, and irrigation treatments but fruit set was not. There was a significant cultivar × ground cover interaction on canker (*Leucostoma* spp.) incidence but not on winter injury. There was a significant cultivar × ground cover interaction affecting tree size and time of defoliation as well as a cultivar effect on defoliation. Soil moisture, soil temperature, and photosynthesis were also studied.

Mycorrhizae. Under local field conditions in Fox sand, the receptivity of colonization by mixtures of indigenous vesicular-arbuscular mycorrhizae was found to be equal for 10 peach seedling rootstocks. Mycorrhizal fungi identified for the first time in peach soils included *Glomus aggregatum*, *G. mosseae*, *G. tortuosum*, *Scutellospora colospora*, and *S. aurigloba*.

Perennial canker. Oxalic acid, a phytotoxic secretion of both the *Leucostoma* (*Cytospora*) spp. that cause peach canker, was found to be associated with the invasion and early pathogenesis of bark tissues. Gas chromatography and histochemistry of tissues inoculated with these pathogens revealed excessive oxalic acid at the advancing edge of lesions. Similar soft rot lesions were produced in peach bark by application of oxalic acid alone. A new scanning electron microscopy technique for locating calcium oxalate was developed based on backscattered electron imaging of silver-stained crystals.

Rootstocks. A peach seedling rootstock experiment was established in 1982 on Fox sand involving nine different rootstocks, with Redhaven as the common scion tester. In 1987 the rootstocks differed significantly in their effect on scion performance for the following traits: total yield, marketable yield, yield of split pits, time of defoliation, and trunk cross-sectional area. Highest yields were obtained on Halford, Lovell, and Bailey rootstocks, which also produced some of the largest trees.

In 1984 an NC-140 peach rootstock experiment was established on tile-drained Brookston clay loam. Ten different rootstocks were evaluated, with Redhaven as the common scion tester. In 1987 significant rootstock effects were noted for scion mortality, bloom date, fruit set before thinning, yield, fruit size, time of defoliation, and tree size. Rootstocks also differed in anchorage ability and degree of suckering. Scion mortality from winter injury, which was related to a rootstock effect on scion acclimation, was unacceptably high for GF677 (78%), GF655-2 (56%), and Lovell (44%). Halford, Siberian C, and Bailey rootstocks performed well on this soil type in 1987.

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Experimental Farm Kapuskasing, Ontario

PROFESSIONAL STAFF

J.G. Proulx, D.V.M.	Superintendent; Beef management

Crop Science

C. Lafrenière,[1] B.Sc.(Agr.), M.Sc.	Forage management and physiology
D. Ouellet,[2] B.Sc.	Cereal management

Experimental Farm, Thunder Bay, Ont.

J. Wilson	Superintendent; Crop management and evaluation

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[1] Located at Rouyn office.

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INTRODUCTION

The Kapuskasing Experimental Farm has a mandate to conduct agricultural research for northern Ontario and northwestern Quebec. The Thunder Bay Experimental Farm reports to Kapuskasing for program orientation and planning. The farm administers a site in northwestern Quebec, from which projects funded by the Entente Canada–Québec will be conducted.

Beef cattle research is conducted in cooperation with scientists from the Animal Research Centre (ARC) in Ottawa. Researchers in ruminant nutrition are currently attempting to determine the influence of the form of protein that is present in forages on ruminant digestion, how it is influenced by cultural practices, and preservation methods. The influence of dietary factors on immune response is also studied in cooperation with the Animal Diseases Research Institute (ADRI) and ARC scientists.

Forage crop research supports the Ontario Forage Crop Committee and the Conseil des productions végétales du Québec. Forage crop production methods and practices are developed to improve ruminant productivity on high-quality all-forage diets. In cooperation with scientists from Sainte-Foy and the Plant Research Centre (PRC), factors that affect persistence of legumes and grass are being studied. In cooperation with ARC and PRC, studies are conducted to determine criteria of quality other than crude protein and acid detergent fiber, which are important for ruminant productivity.

Cereal crop research supports the committees from Ontario and Quebec. Cultural practices for short-season growing areas have been determined, and resources are being shifted towards forage research. Studies in soil and water management, and research to develop methods to solubilize rock phosphate by composting with local peat, are being conducted in cooperation with scientists from the Land Resource Research Center (LRRC).

Further details can be obtained by directing your enquiries to the Kapuskasing Experimental Farm, Research Branch, Agriculture Canada, Kapuskasing, Ont. P5N 2X9; Tel. (705) 335-6148.

J.G. Proulx
Superintendent

ANIMAL SCIENCE

Beef cattle

Estrus synchronization for beef. A 35-day breeding system relying on synchronization of only part of the herd was developed over a 6-year period.

Heat detection was conducted morning and evening for the entire breeding season of 35 days. Cows were bred 12 h after having been observed in standing heat.

For the first 6 days of the breeding season, the cows were bred to the naturally occurring estrus. On day 6, all cows not seen in heat were injected with a prostaglandin product to induce estrus and were bred artificially after heat detection.

Over a 6-year period 1189 breedings were conducted; 35% of the cows were observed in heat during the first 6 days of the breeding season. In cows bred to this natural heat, a pregnancy rate of 84% was recorded. In the remaining cows bred to the induced estrus, 81% were confirmed pregnant in the fall. For the six breeding seasons, an average conception rate of 83.3% was observed.

Calving was concentrated in the first half of the calving season; 70% of the calves were born within a period of 17 days, with the largest percentage born between days 4 and 13 of the calving season.

CROP SCIENCE

Forage management

Forage mixtures in northern Ontario. A total of 21 forage mixtures recommended in Ontario and Quebec were evaluated under a two-cut hay system from 1982 to 1986.

Dry-matter yield, crude protein content, and proportion of grass and legumes were measured for each year. The persistence of the legume in the alfalfa mixtures went from over 65% of the stand in 1982 to 19% in 1983, 17% in 1984, and 6% in 1985. The only exception to this was a mixture with 11 kg/ha of Iroquois and 6 kg/ha of Champ timothy, which still contained over 43% legumes in the 3rd year.

Mixtures with trefoil all contained over 65% legumes in the first production year, except when sown with bromegrass at 10 kg/ha. The mixture of trefoil and reed canarygrass still contained over 70% legumes in 1984. The mixtures with red clover as a base contained between 41 and 57% legumes in 1982; this figure decreased to less than 10% of the stand in 1983, and the mixtures with Ladino never had more then 10% legumes. When Leo trefoil was seeded at 9 kg/ha with Climax timothy at 2 kg/ha (in comparison with Climax at 7 kg/ha) no significant difference in dry-matter yield was found; however, the mixture with Climax at only 2 kg/ha had a significant advantage in percentage and yield of crude protein. There were no yield differences among mixtures of timothy with alfalfa, red clover, or trefoil. However, mixtures with alfalfa or trefoil tended to have a slightly higher protein content. The addition of Ladino clovers in small quantities to a mixture did not produce any advantage in dry-matter yield and protein. Mixtures with timothy and bromegrass tended to have a higher yield and higher crude protein content than orchardgrass.

Forage preservation

Influence of a bacterial inoculant on silage preservation. A stand of orchardgrass was ensiled with a precision chop silage harvester. The harvester was adjusted at a theoretical 8-mm length of cut. Two silos were filled simultaneously and alternate loads were placed in horizontal silos using 150 µm of polyethylene film on each wall and a wide-bottom bale elevator to build the mass. A delivery mechanism was used on the elevator in one silo to add the bacterial culture (Ecosyl®) at 300 000 colony-forming units (CFU) per gram of wet silage. Sealing was done within 8 h.

In a first trial, 6 days after ensiling, the temperature was 2° higher in the silage treated with Ecosyl®. This corresponded to the more rapid drop in pH observed until day 14 in the silage treated with Ecosyl®. At day 51, the pH of the silages was not different. A second trial conducted in the same manner produced similar results. A third trial was conducted to determine the effect of inoculation level on fermentation. Increasing the inoculation from 300 000 to 1 million CFU did not influence the rate of acidification or of the NH_3N content at feeding.

Silages from the first two trials were fed to yearling heifers. At feeding, the dry matter of the silages were 26 and 30%, respectively, for trials 1 and 2, whereas the crude protein was 16.9% and 17.4%. The average daily gain of other yearlings fed these silages was not different. The trial will be repeated under more difficult ensiling conditions.

The top-yielding alfalfa cultivars in 1987 were Magnum at 5094 kg/ha and OAC Minto at 5007 kg/ha, compared with the check Iroquois at 4968 kg/ha. The top-yielding orchardgrass cultivars were S.F.8501 at 5655 kg/ha and Kay at 5460 kg/ha compared with the check Hallmark at 3828 kg/ha. The top-yielding meadow foxtail was M38569 at 4327 kg/ha and G4550 at 4163 kg/ha.

Cereal management

Barley row spacing and seeding rates. Leger barley was sown at four row spacings: 10, 14, 18, and 22 cm; it was subdivided into four seeding rates: 200, 300, 400, and 500 seeds per square metre of soil during the period 1985–1987. A row spacing of 10 cm produced the highest grain yield for all 3 years. Over the 3-year period, a 14.9% grain yield increase was achieved when the row spacing was changed from the conventional 18 cm to the more intensive 10 cm. The data from 1986, which happened to be the best cereal production year, showed a yield increase of only 8.9% when the spacing was changed from 18 cm to 10 cm. There were no significant differences in lodging, plant height, and weight per hectoliter as a result of the four row spacings.

Seeding rates were not responsible for any significant differences in grain yield and straw strength. As the seeding rate was increased from 200 to 500 seeds per square metre, plant maturity and height decreased. Tillering increased from 1.63 stems per plant to 2.65 stems per plant as seeding rates were decreased from 500 to 200 seeds per square metre. Increasing the seeding rate resulted in a decrease in weight per 1000 kernels from 34.2 g to 32.3 g. The weight per hectolitre was not affected by the different seeding rates.

There was no significant interaction between row spacing and seeding rate for any of the agronomic characteristics studied. However, the highest grain yield of 8361 kg/ha was obtained in 1986 under a spacing of 10 cm and a seeding rate of 400 seeds per square metre.

Cereal tests included the Ontario regional oats and barley trials. The top-yielding barley cultivars were Sophie at 1821 kg/ha and Albany at 1815 kg/ha. The top-yielding oat cultivars were Dumont at 1648 kg/ha and Baldwin at 1544 kg/ha. Yields were severely affected by the lack of precipitation in June.

PUBLICATIONS

Research

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London Research Centre
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Mode of Action of Selected and Potential Insect Control Agents

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C.J. Bolter,[2] B.Sc., M.Sc.	Fumigation – toxicology
T. Dumas, D.C.E., M.Sc.	Analytical chemistry – fumigants
R.M. Krupka, B.A., M.A., Ph.D.	Biochemistry
T.T. Lee, B.Sc., Ph.D.	Plant biochemistry and tissue culture
E.B. Roslycky, B.Sc., M.Sc., Ph.D.	Microbiology
A.N. Starratt, B.Sc., Ph.D., F.C.I.C.	Chemistry – natural products
R.W. Steele, B.Sc., Ph.D.	Neurochemistry
A. Vardanis, B.Sc., M.Sc., Ph.D.	Insect biochemistry

Mode of Action of Selected and Potential Plant-Pathogen Control Agents

E.W.B. Ward, B.Sc., M.Sc., Ph.D.	Section Head; Plant pathology – phytoalexins
D.A. Cuppels, B.A., M.S., Ph.D.	Phytobacteriology – molecular genetics
G. Lazarovits, B.Sc., M.Sc., Ph.D.	Plant pathology – soil borne diseases
C. Madhosingh, B.S.A., M.A., Ph.D.	Microbial biochemistry and pathology
A. Stoessl,[3] B.Sc., Ph.D., F.C.I.C.	Chemistry – phytoalexins and mycotoxins
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R.A. Chapman, B.Sc., M.Sc., Ph.D.	Analytical organic chemistry
D.G.R. McLeod, B.S.A., M.S., Ph.D.	Insect physiology
J.H. Tolman, B.Sc., Ph.D.	Applied entomology
A.D. Tomlin, B.A., M.Sc., Ph.D.	Pesticide ecology
C.M. Tu, B.Sc., M.Sc., Ph.D.	Microbiology
S.A. Turnbull, B.Sc., M.Sc.	Insect toxicology

Departures

E.J. Bond, B.S.A., M.Sc., Ph.D., D.I.C. Retired 10 July 1987	Fumigation – toxicology
D.M. Miller, B.Sc., M.Sc., Ph.D. Retired 31 July 1987	Biophysics – fungicide selectivity
T. Nagai, M.E., M.Sc., D.Sc. Retired 22 January 1987	Neurophysiology

VISITING SCIENTIST

R.C. Zimmer, B.Sc., Ph.D. Transfer of work from Morden Research Station	Plant diseases

Visiting fellows

M. Butler, B.Sc., Ph.D.	Plant pathology
D. Cahill, B.Sc., Ph.D.	Plant pathology
K.R. Hynes, B.Sc., M.Sc., Ph.D.	Biotechnology – Plant pathology
R.A. Moore, B.Sc., Ph.D.	Plant pathology

Graduate students

K. Lee, B.Sc., M.Sc.	Biochemistry – fungicides
R. Schwartz, B.Sc.	Phytobacteriology

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[2] Education leave, University of Western Ontario, London, Ont.

[3] Transfer of work, August 1986–August 1987, University of British Columbia, Vancouver, B.C.

[4] Transfer of work, August 1986–August 1987, North Coast Agriculture Institute, Collongbar, Australia.

INTRODUCTION

This report summarizes highlights of research carried out during 1987 at the London Research Centre in support of departmental objectives in environmental quality and crop protection. The centre was established in 1951 to investigate the problems created by the introduction of synthetic organic pesticides. Present research programs reflect the current concerns about health and the environment regarding the agricultural use of pesticides by concentrating research efforts in integrated pest management (IPM) and environmental toxicology.

The IPM objective comprises four research activities. The pest management activity is aimed at developing IPM procedures, including biological control, for agriculturally and economically important insect pests. Research on stored products is directed toward the investigation of environmental and insect resistance problems and the development of more efficient fumigation procedures leading to a minimum of pesticide residues. The third activity concerns research on alternative pest control strategies. Studies on insects are aimed at identifying specific areas for attack so that pest control in the future will not rely upon the use of broad-spectrum toxicants. Research on natural plant defense mechanisms in disease-resistant and susceptible agriculturally important crops has the objective of using natural defense mechanisms by biotechnology, chemical manipulation, or the breeding of resistant cultivars. The last activity under the IPM objective concerns research on systemic fungicides. Studies are carried out on the efficacy of systemic fungicides and on the plant pathological, biochemical, biophysical, and structural parameters of fungicide activity and resistance.

Research on environmental toxicology has three areas of activity. The first deals with the effect of pesticides on nontarget soil invertebrates and agriculturally important soil microorganisms. The second is concerned with the determination of the behavior, persistence, and environmental fate of pesticides and their movement through the environment. The third is concerned with establishing the mode of action of growth regulators and toxicants by carrying out studies on insects and plants related to vital processes of growth and development.

July 1987 saw the long-awaited sod-turning ceremony for the new pest management building at Packs Lane. During 1987 three scientists retired with a combined total of 92 years of service with the branch: Dr. E.J. Bond, 36 years in fumigation research; Dr. D.M. Miller, assistant director, 36 years in biophysical chemistry research; and Dr. T. Nagai, 20 years in insect neurophysiology.

This report records only the highlights of our accomplishments for 1987; more detailed information can be obtained from the publications listed at the end of this report. Copies of this report, reprints of publications, and further information are available on request from the Research Centre, Agriculture Canada, 1400 Western Road, London, Ont. N6G 2V4; Tel. (519) 679-4452.

H.V. Morley
Director

INTEGRATED PEST MANAGEMENT

Control of the onion maggot

Further progress was made on feasibility studies aimed at incorporating biological control, using parasites and predators, into an integrated pest management program.

Although *Aleochara bilineata* (AB) survives the winter in diapause as a first-instar larva within the host puparium, laboratory studies showed storage at -3°C to be lethal to AB larvae after 8 weeks. Experiments are in progress to clarify the means of overwintering by AB and to determine whether diapause AB can survive periods of flooding. At 20°C, postdiapause onion maggot (OM) pupae survived flooding for only 2 weeks; at 1°C OM pupae survived at least 10 weeks. Postdiapause larvae of the braconid wasp, *Aphaereta pallipes* (AP), survived flooding for up to 8 weeks at 20°C and at least 12 weeks at 1°C. Should spring flooding become the preferred method of control for white rot, potentially a very serious disease of onions, the above observations will prove useful in developing integrated control strategies for OM.

In field microplot tests, release of as few as 16 AB per square metre significantly increased parasitism of OM pupae; furrow granular application of chlorpyrifos did not significantly reduce OM parasitism by AB. In a large-scale field trial to test the effectiveness of released AB for control of second-generation OM, five AB per square metre were regularly released biweekly on the Thedford–Grand Bend Marsh. At harvest, onion damage was no higher in the release block than in the remainder of the field treated with four foliar insecticide sprays. Parasitism of OM pupae also was higher in the release block until onions were pulled for harvest; with reduced cover released AB appeared to disperse further from the study.

A study was begun to assess the feasibility of releasing AB, to suppress root maggots in home gardens. In all cases, there was less damage in release gardens than in control gardens. It also was shown that AB will move up to 4–5 km in the urban environment.

Releases of marked *Scatophaga stercoraria* (SS) parasitoids were monitored at the Pack's Lane Field Station using sweep netting and attractant artificial manure pats from May to September. The experiments were designed to establish adult activity under natural temperature and humidity regimes and to compare activity in woodland with adjacent cultivated fields. Results indicate the adults were active in woodland for most of the frost-free season, but in cultivated fields they were active only at air temperatures below 29°C. Marked recaptures of flies also revealed significant movement between field and woodland sites.

In further studies to assess the feasibility of using the fungus *Entomophthora muscae* (EM) as a biological control agent for dipterous insect pests, success in cultivating EM in an insect tissue culture medium led to an attempt to grow the culture to determine growth characteristics and the formation of conidia or resting spores. Among 270 media examined, excellent growth of the fungus occurred on only four media. Although the fungus was grown as a saprophyte, by periodic transfers it retained its parasitic potential for more than 2 years. However, on the media tested, the fungus did not produce conidia or resting spores. The most satisfactory temperature for rapid development of normal growth and production was 17°C. Microscopic observations suggested that protoplasts multiplied by budding and colonized. A cell wall formed resulting in a spherical structure that germinated by the formation of a germ tube.

Assessment of the toxicity of insecticides to parasites and predators of dipterous insect pests was continued. Permethrin was 3.8 times more toxic to OM than to SS. Attempts to select a diazinon-resistant strain of AB produced a slight increase in resistance (×5.6) compared with a more susceptible strain.

Field microplot studies verified the effectiveness of the organophosphorus insecticides chlorpyrifos and fonofos and the growth regulator cyromazine applied as seed dressings for control of first-generation OM. Cyromazine, SD-208304, and SC-0567 also provided good control of first-generation OM when applied in the seed furrow. Chlorpyrifos, commercially pelleted around onion seed, also provided effective control of first-generation OM, not only in field microplots but also when planted by growers on the marshes of Thedford–Grand Bend, Holland, and Keswick. Increased incidence of onion smut was, however, noted on the Keswick Marsh.

Monitoring

The earliest, hottest summer on record in southwestern Ontario was expected to create problems for the insect pest monitoring program, but prediction of the extra generation of the European corn borer was successful. The development of aestivation in the late summer also reduced the number of generations of the cabbage maggot (CM). The Pest Alert, produced cooperatively with the Ontario Ministry of Agriculture and Food, successfully alerted producers to these changes in the likelihood of infestation by the insects, allowing adjustment of spray schedules. Three commercial preparations of corn borer pheromone were evaluated and compared with the centre's preparation. The centre's pheromone traps caught 4 times as many moths as the best commercial preparation. Two commercial pheromone preparations worked equally well for monitoring the corn earworm. Of three commercial pheromone preparations available for the cabbage looper, two worked well and the third caught no moths but smelled wonderful!

The turnip mosaic virus (TUMV) problem in rutabagas this year was less severe than last year. This improvement resulted primarily from reduced crop areas of winter rapeseed caused by heavy winter kill and lower fall seeding rates because of reduced price for rapeseed and the effect of TUMV on winter rapeseed yield. Monitoring this year concentrated on flea beetles and aphids. The ability to identify seven species of aphids found in rutabaga fields has allowed the process of establishing the temporal distribution relationship of aphids with TUMV infection in the field to start. Preliminary results indicate that the three colonizing aphids, *Brevicoryne brassicae* (cabbage aphid), *Myzus persicae* (green peach aphid), and *Lipaphis erysimi* (turnip aphid) do not occur when the virus is spread to the turnip fields but could be responsible for spread within the field. Several grain aphid species occur at the proper time and have been recovered from rutabaga fields. Peaks of *Rhopalosiphum padi* occur as winter grain is drying down. There was some indication last year that flea beetles might be involved in transmission of TUMV, but experiments this year were inconclusive.

Enhanced microbial degradation

Previous work has shown that under certain conditions microbial populations in soils rapidly acquire the ability to degrade many carbamate and organophosphorus pesticides. This enhanced microbial degradation results in erratic pest control that may, in fact, be erroneously attributed to development of insect resistance.

Two studies on enhanced microbial degradation of insecticides in soil were completed. A 3-year study comparing the persistence in a clay loam of single and repeated annual applications of seven granular insecticides used for corn rootworm control showed that the persistence of chlorpyrifos, terbufos, and phorate was relatively constant over the 3 years and between plots receiving single and multiple treatments. Disulfoton and fonofos behavior was more variable and that of carbofuran and isofenphos was extremely variable. Anti-insecticide activity against carbofuran and isofenphos was detectable 2 weeks after an initial application and was still present the following spring. Anti-insecticide activity against fonofos, terbufos sulfoxide, phorate sulfone, and disulfoton sulfone also was generated in this soil. Anti-insecticide activity against chlorpyrifos, disulfoton, terbufos, and phorate was not present. Carbofuran, chlorpyrifos, and terbufos, (plus metabolites) present in the upper 5 cm of soil averaged 93, 94, and 94%, respectively, of the total core contents over 12 weeks. Significant moisture-dependent differences were observed between the behavior of granular carbofuran and granular isofenphos in anti-insecticide active soils.

In the second long-term study, compilation of field efficacy data accumulated over a number of years indicated that CM control by carbofuran and fensulfothion in Newfoundland has declined with time. A similar trend was apparent in Ontario, with carbofuran used to control carrot rust fly (CRF) and carrot weevil (CW). Laboratory tests conducted with two Newfoundland CM strains and an Ontario CRF strain indicated that declining efficacy could not be attributed to the development of insect resistance to recommended insecticides. Other tests indicated that the two Newfoundland soils developed the capacity for rapid degradation of carbofuran or fensulfothion in a single growing season. In an organic soil used for carrot production in Ontario, anti-carbofuran activity was apparent within 1 week after application of granular carbofuran in the seed furrow and was high after 3 weeks. The data suggest that development in the soil of microbial populations capable of enhanced degradation of carbofuran and fensulfothion is contributing to the erratic performance of these insecticides in CM, CRF, CW, and other root maggot control programs in Canada.

Insect rearing

At the present time a total of 41 strains of 17 different insect species are being reared in the centre. A total of 18 field cultures were received, reared, and increased as necessary for resistance screening tests; most collections followed grower inability to control Colorado potato beetle (CPB). An effective, efficient mass-rearing technique for SS is now in operation; many thousands were released in dispersal studies during the summer. Quality control tests to evaluate performance of mass-produced AB are being developed.

Insecticide resistance

In studies on the development of insecticide resistance, CM from an area of Newfoundland that had been monitored for many years showed no indication of resistance to carbofuran, fensulfothion, or diazinon. Ten collections of CPB from Ontario and eastern Canada were monitored for resistance to insecticides. Five cases of more than 100-fold resistance to carbofuran and several of pyrethroid resistance were found. Other CPB-insecticide studies involved cross-resistance, joint action, and knockdown recovery at low temperatures. A study of the effect of selection of resistant house flies with a pyrethroid-synergist combination was completed when resistance levels dropped to less than 10-fold after 32 generations without selection pressure. The pattern and rate of resistance development were similar to that with the pyrethroid alone. A cross-resistance study showed intermediate but significant levels of cross-resistance to other pyrethroids.

Other studies. In collaboration with Vineland, soil fauna in solarized and unsolarized plots in potato fields in sandy soils at Alliston, Ont., were compared. These soils were exceptionally impoverished of soil arthropods in both solarized and unsolarized conditions, but highly significant reductions in free-living nematodes in solarized plots were observed.

In collaboration with the Soil Survey Unit of Agriculture Canada, Yukon, it was determined that large "worms" collected from soliflucted soils in the Richardson Mountains were Enchytraeid and not Lumbricid earthworms. These Yukon soils, unlike most other Canadian soils, including our best agricultural soils in southern Ontario, were not glaciated. The implications of glaciation for worm distributions (Enchytraeid or Lumbricid) in Canada are significant.

No planting treatment alone provided commercially acceptable season-long control of CM attacking rutabagas in microplot studies. A program of three drenches of chlorpyrifos provided best control, and two drench applications of chlorpyrifos following planting application of granular terbufos, chlorpyrifos, and SD-208304 also gave acceptable control.

STORED PRODUCTS

Since phosphine is known to be unstable at very low pressures and can cause fire and explosions under some conditions, a study was undertaken to establish explosive limits over a range of pressures and concentrations so that any hazardous procedures involving excessive pressure changes in practical fumigation treatments could be avoided. A test method for studying the combustibility of gases at reduced pressures has been developed and has been used to determine the minimum combustible concentration of phosphine in 99.99, 20.99, and 5% oxygen at pressures down to 150 mm Hg. The lowest concentration where combustion occurred at 25°C was found to be 1.67% phosphine in 5% oxygen at 150 mm Hg.

The DNAs of corn and wheat have been shown to be methylated during treatment with methyl bromide, a fumigant widely used to control insects in foodstuffs and other commodities. Using ^{14}C labeling, the N-7 position of guanine and the N-1 position of adenine were identified as the major sites of methylation. Alkylation also occurred at N-3 of cytosine, adenine, and guanine. Although less than 1% of the bound radioactivity found in the grains was associated with the isolated DNA, results indicated that 0.5–1% of the guanine residues in the DNA were methylated during treatment with methyl bromide at 48 mg/L for 72 h. It seems probable that methylation of nucleic acids is a contributing factor to the observed loss of viability of seeds treated with this fumigant.

Studies in fumigation of wood chips with phosphine and methyl bromide showed that the fumigants did not easily penetrate the mass of material in sufficient quantities to kill the pinewood nematode. At 21°C the concentrations of the fumigants decreased rapidly as the gas diffused through the chips so that for the fumigant phosphine the concentration had decreased by 50% at 0.7 m from the point of application, and at 2 m it was less than 5%. Similarly the fumigant methyl bromide did not penetrate deeply; however, it could be uniformly distributed through the mass of wood chips if a recirculation procedure was used. Both fumigants were rapidly and irreversibly sorbed by the wood chips so that concentrations were reduced to levels below those required to kill the nematodes.

A project on the fumigation of hay with phosphine for control of Hessian fly has been initiated to comply with quarantine requirements on hay exports from Canada to Japan. Collections of wild Hessian fly were obtained from the provinces of Alberta, Saskatchewan, and Manitoba to establish laboratory culture for mass rearing of the insects for toxicity studies. Facilities, equipment, and techniques for rearing of the insect have been developed and are now in place; although some problems associated with sex distribution and diapause of the insects have been encountered, a strong colony of breeding stock has been established.

With this colony, large numbers of insects can now be produced to carry out the fumigation experiments necessary to provide the required data and to develop the necessary recommendations and procedures for commercial treatments.

ALTERNATIVE PEST CONTROL STRATEGIES

Research in this area is directed toward obtaining an appreciation of the basic processes involved in plant–pathogen interactions in resistant and susceptible crops and the role of phytotoxins in pathenogenicity. The potential benefits of these studies would be the ability to activate the plants' natural defense mechanisms and to provide new methods for introducing disease resistance into crop plants.

Phytoalexins. Research was completed on the biosynthesis and metabolism of glyceollin I in wounded and infected soybeans. The study resolved the problem of whether accumulation of glyceollin is due to differences in rates of synthesis and metabolism in resistant and susceptible plants. Evidence had been presented by others that differences in rates of metabolism could account for differences in accumulation. Results obtained here established that metabolic rates in all tissues were similar and therefore did not differentially affect accumulation. Distinct differences in biosynthetic rates were demonstrated to develop at the earliest stages following infection, being highest in resistant responses. Wounding alone was also demonstrated to stimulate biosynthesis, but metabolic rates are such that glyceollin I does not accumulate. Accumulation in the resistant response is related to the enhanced biosynthesis that develops, and this is consistent with evidence for gene transcription and enzyme activity.

Phytotoxins. A 30-kilobases (kb) fragment selected from a cosmid (pLAFR1) library of wild-type bacterial speck pathogen *Pseudomonas syringae* pv. *tomato* DNA, from the laboratory collection, restored pathogenicity to the Tn5-induced mutant DC3481 but not to any of the other Tn5-induced pathogenicity mutants. In the presence of this fragment the mutant also regained the ability to use citric acid cycle intermediates as carbon sources, a trait that also had been lost as a result of the single-site Tn5 insertion mutation. Subsequent subcloning of this 30 kb fragment revealed that the DNA sequence essential for restoration of pathogenicity was approximately 4 kb. When the pLAFR1 wild-type library was mated with the Tn5-induced toxin-minus mutant DC3661, one out of 171 transconjugants assayed on tomato plants was able to produce the toxin coronatine. The cloned fragment able to restore toxin production to DC3661 was approximately 33 kb. When subcloned, only 7 kb of this fragment proved essential for toxin synthesis by DC3661. The larger fragment complemented four of five other of toxin-minus mutant strains in the collection. Thus, segments of the *P. syringae* pv. *tomato* genome that are essential for tomato plant infection and for coronatine synthesis have been identified and isolated.

Biosynthetic studies on traversianal, a recently (1986) discovered metabolite of the plant pathogen *Cercospora traversiana*, were completed with the demonstration that the compound is formed on a route that differs substantially from those leading to the structurally related phytotoxins and mycotoxins of the fusicoccane and ophiobolane groups. In another context, this compound was shown to cause the lysis of plant cells (beet root), but surprisingly, it was shown to have no other discernible phytotoxic properties. However, it lysed human red blood corpuscles and was exceptionally toxic to brine-shrimp larvae and snails. Therefore, traversianal should probably be further examined as a putative mycotoxin as well as a potential molluscicide.

In related studies, the mutagenic phytotoxin dothistromin, a metabolite of *Dothistroma pini* and many *Cercospora* spp., was found to exhibit previously unreported antimicrobial and lytic activities that were strongly but not entirely light- and oxygen-dependent; and to be moderately toxic to brine-shrimp larvae in a nonlight- and oxygen-dependent manner.

The effect of tricyclazole, an inhibitor of pentaketide melanin biosynthesis, on three isolates of *Alternaria solani* and *Verticillium dahliae* was investigated. At all tricyclazole levels tested, *Alternaria* cultures primarily accumulated the melanin shunt product 2-hydroxyjuglone (2-HJ). The concentrations of 2-HJ depended on medium composition, fungal isolate, culture age, and light exposure. With *Verticillium*, increasing levels of tricyclazole resulted in progressively decreasing quantities of 2-HJ and increasing quantities of another shunt product, flaviolin. Concentrations of 2-HJ in cultures of both fungi grown on Czapek Dox agar were high enough to inhibit fungal growth on thin layer chromatograms. In the presence of tricyclazole, the accumulation of the phytotoxin altersolanol A, produced by isolate 83W of *A. solani*, was reduced by 20–100%, depending on inhibitor concentration, culture age, and light exposure. Generally, factors which increased the accumulation of 2-HJ suppressed the production of altersolanol A. The results support the view that melanin in *A. solani* is of a dihydroxynaphthalene origin, and not a mixed polyketide-shikimate origin. The apparent inhibition of altersolanol A accumulation by tricyclazole treatment is a separate phenomenon, not directly linked to melanin biosynthesis, since 1,3,6,8-terahydroxynaphthalene, a key melanin precursor, cannot be an intermediate of altersolanol A biosynthesis. Nevertheless, it suggests that there are additional mechanisms whereby tricyclazole may interfere with factors essential for pathogenicity.

Insect pests

Research in this area is directed toward gaining an understanding of basic life processes peculiar to the insect so that methods of selective, specific control can be developed that do not rely upon broad-spectrum toxicants.

Proctolin. Study of a cockroach body fraction that was retained on a Norganic resin column but not on Sep-Pak C18 cartridges indicated the presence of additional factors capable of inhibiting contractions elicited by proctolin. This material probably has a much lower molecular weight than the neutrolins. New HPLC systems have measurably improved yield of myoactive substances, and they show promise in overcoming enzyme stability problems encountered with proctolin regulatory proteins.

Chitin. Work continued on a model system aimed at obtaining some general understanding of the principles involved in particulate substrate-enzyme complexes. By the use of high performance liquid chromatography, those particles that carry the biosynthetic and degradative enzymes that act on the polymer have been successfully separated. The use of various chromatographic media that separate on the basis of either molecular weight or overall charge or hydrophobic interaction has allowed the separation of enzymes and associated particles from each other. The results show that specific particles, very much the minority with respect to the total population of particles, are the carrier of these enzymes. It is important now to attempt to investigate the properties of these particles in order to understand their interaction with the respective enzymes. The importance of this work lies in its relationship to the insect molt, which is considered to be a likely target site for future pest control measures.

In relatively few cases is the cellular target site of pesticides known and understood. A suggested site of action is the cell membrane, though this is usually hard to prove. No simple test system is available to pinpoint pesticide action at this level. An ideal system would be a membrane system independent of other cellular processes. One possibility would be reconstituted membrane vesicles, but such systems are hard to work with and prepare. Systems have now been developed here having the advantages of vesicles, and they are readily available and easy to assay. These are the glucose and the choline transport systems of red cells. The red cell is particularly suitable because it contains no nucleus and no mitochondria, it has an extremely low level of metabolic activity, and transport is independent of energy metabolism. Moreover, knowledge gained in previous studies on this system allows the use of simple techniques to determine whether a pesticide interferes with transport by action on the carrier specifically or by generalized effects on the cell membrane.

ENVIRONMENTAL TOXICOLOGY

Work directed toward determining the movement and persistence of pesticides in the environment was continued.

Mobility and persistence studies. Field-based lysimeters packed with Plainfield sand were used to study mobility and persistence behavior of commercial formulations of the herbicides atrazine, metolachlor, and terbuthylazine under two precipitation regimes: natural rainfall and natural rainfall with supplementary watering. Ater 21 weeks under natural rainfall, the maximum movement of atrazine, terbuthylazine, and metolachlor was, respectively, 30, 20, and 10 cm; under supplementary watering it was, respectively, 70, 50, and 40 cm. With the exception of a single trace of atrazine, no herbicide appeared in the effluent of natural rainfall cores. Both atrazine and terbuthylazine appeared somewhat susceptible to sudden leaching following heavy precipitation during the week following their soil application. Soil-water partitioning coefficients generated for the three herbicides on Plainfield sand decreased in the following order: terbuthylazine > metolachlor > atrazine.

Impact of pesticides on nontarget organisms. Effects of four experimental chemicals – Dowco 429X, SD-208304, tefluthrin, and trimethacarb – on soil microbial activities were evaluated. None of the chemicals caused effects serious enough to be considered deleterious to microbial activities important to soil fertility.

The effect of thiram, captan, and thiabendazole seed treatments on 16 strains of thiram-resistant *Rhizobium japonicum* was determined. Six isolates were unaffected by the fungicide applied singly or in combination at 2000 ppm.

Contrary to published reports, sethoxydim was shown to have an unexpectedly long residual effect on root growth. Recent studies of cellulose hydrolysis in soil over a period of 3.5 years revealed initial stimulation of the process followed by suppression by practical concentrations of sethoxydim.

A study of adaptations of selected rhizobia and agrobacteria to paraquat demonstrated that paraquat resistance was a stable characteristic and not a function of adaptive enzymes. The increase in resistance to the herbicide resulted in an increase in the resistance to ultraviolet radiation and to various antibiotics. Increasing paraquat concentrations gave rise to a higher number of mutants resistant to the antibiotics.

A large variety of new heterocyclic carboxamides including furans, thiophenes, oxathiins, and substituted benzanilides were synthesized and tested for inhibitions of the target site enzyme complex (succinate-ubiquinone reductase; Complex II) in mitochondria from a wild-type strain and a carboxin-resistant mutant strain of corn smut, *Ustilago maydis*. A number of compounds were highly active inhibitors of the enzyme complex, and some 4'-substituted analogs, in particular, were selectively active towards the resistant enzyme. Some compounds were active inhibitors of the growth of the pathogen *Rhizoctonia solani* and could prove potentially useful as fungicides.

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Vineland Station, Ontario

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INTRODUCTION

The Vineland Research Station serves the horticultural industry with comprehensive crop protection research that is organized under four multidisciplinary programs: tree fruits, grapes and berries, vegetables, and ornamentals. Scientific disciplines represented at the station include entomology, acarology, ecology, mycology, virology, bacteriology, nematology, pesticide residue chemistry, toxicology, and computer science. The Smithfield Experimental Farm, located near Trenton, is administratively linked to the station and carries on horticultural production and processing research, as well as pest control programs, in collaboration with Vineland.

This report summarizes some of the research results from the station in 1987; more detailed information can be obtained from the publications listed at the end of the report. For more information on these or other research projects, or for copies of this report, please write to the Director, Research Station, Research Branch, Agriculture Canada, Vineland Station, Ont. L0R 2E0; Tel. (416) 562-4113.

D.R. Menzies
Director

TREE FRUITS

Insects and mites

Red mite resistance to acaricides. Populations of European red mite, showing 9× resistance (R) to cyhexatin, crossed with susceptible (S) mites to produce an F_1 strain with 3× resistance. Back-cross tests indicated that cyhexatin resistance was complex, i.e., multigenic, and did not adversely affect fecundity, life span, sex ratio, or rate of development. Caged F_1 (R × S) mites lost cyhexatin resistance after four to six generations, consistent with resistance being multigenic. With mites showing 15× dicofol resistance, crosses between R and S populations produced a strain similar in response to the S strain. Back crosses indicated a single recessive gene for resistance. Dicofol R and S populations were similar in fecundity, life span, sex ratio and development rate. Caged F_1 (R × S) mites showed persistent dicofol resistance over eight generations. Crosses between cyhexatin R and dicofol R strains, followed by selection with mixtures of both acaricides, produced strains showing resistance to both acaricides.

Survey of spring-feeding Lepidoptera. Twenty-six species of spring-feeding Lepidoptera in six families were recovered from unsprayed apple orchards at several localities in southern Ontario. The obliquebanded leafroller, the eyespotted bud moth, and the pale apple budworm, *Pseudexeutera mali* Freeman, caused considerable damage to the foliage and fruit and should be regarded as potential pests where they occur in managed orchards.

Serological monitoring of predation and parasitism. Species of *Pterostichus, Harpalus, Amara, Diplocheila, Bembidian, Clavina*, and unidentified species of staphylinids and araneids were serologically determined as predators of the codling moth, apple maggot, spotted tentiform leafminer, and apple aphid from 2500 specimens collected in orchards. Polyclonal and monoclonal antisera were prepared to eggs and cocoons of *Pholetesor ornigis* Weed. Mass rearing of *P. ornigis* produced 51 adults per seedling in flats containing 30 apple seedlings. On dwarf apple trees, a maximum of 563 adult *P. ornigis* were obtained from a single tree.

Nematodes

Chemical control of root-lesion nematode, Pratylenchus, on apple. Paulared apples on MM106 rootstock were planted at Smithfield in May 1979. Products and rates applied were as follows: Vorlex (110 L/ha) and Dazomet 98% (55 kg/ha) in the fall of 1978 before planting; Temik 15 G (45 kg/ha), Vydate 10 G (70 kg/ha), and Nemacur 3 (45 L/ha) annually in the spring; Vydate L (15 L/ha) as three foliar sprays annually; and Vorlex plus Vydate L (rates and timing as above). Trees receiving the Vydate granular, Nemacur, and Dazomet treatments had the largest trunk area and cumulative yield from 1982 to 1985. All treatments had significantly lower root-lesion nematode populations than the untreated control in fall 1980 and 1981; however, after 1981, Vorlex and Dazomet plots contained as many nematodes as the control. Only Temik and Nemacur provided consistent root-lesion nematode control over the years.

Diseases

Peach canker, Leucostoma cincta, L. persoonii. In xylem tissues of peach following mechanical wounding, thin intracellular suberin lamellae were detected in ray and axial parenchyma, or both, located near the wound surface. In a visible, discolored wound reaction zone, xylem vessels and fibers were often found plugged with amorphous material or occluded by tyloses. Suberized xylem parenchyma cells appeared discontinuous or often restricted only to occasional cells. However, continuous boundaries were formed from conjoined suberized parenchyma cells and tylosed or occluded vascular elements.

At 7 or 10 days after wounding, irrigation did not influence formation of the primary ligno-suberized boundary zone on scaffold limbs of either Candor or Redhaven peaches. Significantly greater numbers of suberized necrophylactic phellem cells resulting from irrigation were found in Candor by the 14th day after wounding. Lignin deposition in the boundary zone was not influenced by irrigation. Necrophylactic periderm generation rate in Redhaven was not influenced by irrigation.

NaCl injury to dormant roadside peach trees. Loring peach trees, repeatedly contacted in winter by windblown NaCl spray from an adjacent highway, suffered severe shoot dieback and reduced fruit yield. The percentage of dead canopy wood was positively correlated with Na^+ and Cl^- concentrations and was inversely correlated with distance from the highway. Redhaven peach shoots dipped in NaCl solution showed severe to total bud mortality at 6.2–13.0 mg of Na^+ per gram of dried shoot. Na^+ was absorbed readily at 90% RH; phytotoxicity was maximal after incubation at 90% RH for 8 days at 5°C.

Efficacy and stability of newly developed benzimidazole fungicides. Methyl (MBC-MIC) and ethyl (MBC-EIC) isocyanate homologues of benomyl (MBC-BIC) protected apples against benomyl-resistant (R) *Botrytis cinerea.* MBC-EIC and MBC-MIC gave 95% protection (EC95) at a concentration of 356 M and 824 M against a benomyl-sensitive (S) isolate. Against the R isolate, MBC-EIC and MBC-MIC had EC95 concentrations of 943 μM and 1601 μM, respectively, whereas MBC-BIC and the hexyl isocyanate homologue (MBC-HIC) showed no fungicidal activity even at 3170 μM. These homologues degraded slower at 1°C than at 25°C; MBC-MIC and MBC-EIC degraded faster than benomyl, and MBC-HIC degraded slower.

GRAPES AND BERRIES

Diseases

Infection sites and fungicidal prevention of Botrytis cinerea bunch rot of grapes in Ontario. In 1981, infection of berry clusters by *Botrytis cinerea* berry clusters represented 11, 7, and 4 infection foci in each cluster of Chardonnay, Seyval, and Aurore cultivars, respectively. Clusters infected in July and August ranged from 22% for Aurore and Seyval, to 46% and 92% for a tight-cluster and a loose-cluster clone of Chardonnay, respectively. Cluster infection declined slightly between flowering and cluster closure but increased during ripening. Four to five applications of iprodione or vinclozolin controlled bunch rot in Gamay, Seyval, and Chardonnay, but iprodione failed to protect Aurore clusters with split berries. To delay the development of iprodione resistance in *B. cinerea*, best application times were when the berries were pea-sized and again at cluster closure to early ripening.

VEGETABLES

Insects

Diapause in the carrot rust fly. The percentage of diapause in overwintering carrot rust fly pupae at the Holland Marsh in 1982–1983, 1984–1985, and 1985–1986 increased with time of sampling from late September, reaching 100% in late November or early December. In pupae overwintering in the ground at Vineland, the percentage in diapause decreased from January until early April, when diapause was virtually absent. A low incidence of diapause detected in early spring collections from the Holland Marsh indicated this factor should be considered in degree-day models being developed for the carrot rust fly.

Tarnished plant bug as a pest of celery. In greenhouse and field cage trials, adult tarnished plant bug (TPB) on celery plants caused lesions ranging from pin-point size to ovoid cavities in the main petioles, with necrosis of leaves and stalks. When insecticide-free plots of celery were monitored for TPB, lesions of the type observed in the cage studies increased in abundance during the season, associated with the occurrence of and increases in TPB activity.

Nematodes

Chemical control of root-lesion nematode, Pratylenchus penetrans. On the potato cultivar Russet Burbank, at recommended rates, Vorlex and Telone II B suppressed population densities of 18 320 and 50 880 *P. penetrans* per kilogram of soil in 1983 and 1984 more effectively than did single applications of Temik 10 G, Vydate L at two rates, and Furadan 10 G. A combination of Vorlex plus Temik resulted in lowest populations at harvest. In 1983 marketable tuber yields (>7 cm) in the plots with Vorlex plus Temik, Vorlex alone, Telone II B, and Temik were 20.7, 17.3, 15.9, and 7.5 t/ha, all significantly better than 4.7 t for the untreated check. In 1984, marketable yields were not improved by any treatment, although total yields (marketable plus undersized) were significantly increased by the fumigants.

Irrigation-water application of metam sodium for root-lesion nematode control. Tioga loamy sand, infested with 18 500 *Pratylenchus penetrans* per kilogram of soil, received metam sodium at 25, 50, 100, 200, and 400 L/ha dissolved in water, equaling a 25-mm drench. The potato cultivar Norchip was planted 19 days later and grown for 152 days. At planting, 100 L/ha had suppressed the initial nematode density by 64%, 200 L/ha by 90%, and 400 L/ha by 100%. At 61 and 152 days, the soil populations at the same three rates were suppressed, respectively, 65 and 66%; 93 and 83%; and 99.8 and 99.4%. Root densities were suppressed by all rates except the lowest.

Oxamyl treatment of potato seed tubers for control of Pratylenchus. Whole and cut potato tubers soaked for 20 min in oxamyl solutions of 1000, 2000, 4000, and 8000 ppm and planted in soil infested with *Pratylenchus penetrans* showed no adverse growth effects; nematodes in the soil and roots declined as oxamyl concentration increased. With oxamyl solutions of 16 000 and 32 000 ppm, shoot emergence was delayed, but at 5 weeks top growth and root growth were unaffected. At 5 weeks, in the soil planted with tubers treated at 32 000 ppm, nematodes were reduced by 73–77%, and in the roots the nematodes were reduced by 92–97%.

Thermal death-point of Pratylenchus penetrans in soil. To interpret the effect of solarization on *Pratylenchus penetrans*, the thermal death-point in Tioga loamy sand was determined by incubating over various time periods at six different temperatures. Fifty and 90% mortality was achieved after 24 and 96 h at 38°C; 6 and 24 h at 39°C; 4 and 12 h at 40°C; 3 and 6 h at 41°C; 2 and 3 h at 42°C; and 1 and 2 h at 43°C.

Diseases

Phoma complanata canker of parsnips and photocarcinogenic furocoumarins. Diseased root tissue from the parsnip cultivar Fullback, inoculated with *Phoma*, contained 100 times more concentration of total furocoumarins than the healthy root tissue from the uninoculated fungicide-sprayed plot. Photocarcinogenic furocoumarins consisting of psoralen, 5-methoxypsoralen, and 8-methoxypsoralen were analyzed using reversed-phase high performance liquid chromatography (HPLC). Some leaf tissues also contained high levels (over 200 µg/g). In laboratory, greenhouse, and field studies, chlorothalonil significantly reduced *Phoma* root canker incidence and foliar disease ratings at harvest, and significantly increased yield of fungicide-sprayed plants. Residues of chlorothalonil and its degradation product DS-3701 were determined by methylating the DS-3701 and using capillary gas chromatography with electron capture detection. Residue levels of chlorothalonil and the metabolite in root tissue at harvest ranged from 0.036 to 0.80 and from 0.014 to 0.031 µg/g, respectively. By reducing disease levels in the field, the levels of photocarcinogenic furocoumarins would also be reduced.

Strip tillage and tomato diseases. Strip tillage for vegetable crops, as a way of reducing production costs and soil erosion, was evaluated for machine-harvested processing tomatoes planted into killed rye and oats. No effect of tillage on yield was found for 2 out of 3 years. Yield was reduced in the 3rd year in strip-tillage rye plots because of low transplant vigor and possibly low temperature injury. Populations of plant parasitic nematodes were stimulated by rye and strip tillage. Bacterial diseases were increased by strip tillage in one season.

Effects of controlled atmosphere storage on Sclerotinia sclerotiorum and watery soft rot of celery. At 1°C, growth of *Sclerotinia sclerotiorum* (Lib.) de Bary on celery agar was suppressed the most in a storage atmosphere containing 7.5% CO + 1.5% O_2 but only slightly in 4% CO_2 + 1.5% O_2 or in 1.5% O_2 alone compared with normal air. Watery soft rot caused by this fungus on celery in normal air after 2 weeks at 8°C was as severe as on celery stored for 10 weeks at 1°C. At 8°C the suppression of this disease was greatest in atmospheres of 7.5–30% CO + 1.5% O_2 and only slightly reduced in 4–16% CO_2 + 1.5% O_2 or 1.5–6% O_2 alone.

Turnip mosaic virus in Ontario vegetables. Turnip mosaic virus (TuMV) was collected from cruciferous and other hosts, including Chinese vegetables and lettuce; six strains of TuMV have been identified on Chinese cabbage differentials. A highly specific monoclonal antiserum was produced to TuMV. The rutabaga cultivars Sensation and Calder were immune to the Ontario isolate of TuMV. In crosses of susceptible Laurentien with resistant line 165, TuMV resistance was determined by a single dominant gene.

ORNAMENTALS

Insects and mites

Interaction of chrysanthemum leafminer, Liriomyza trifolii (Burgess), with bacterial leafspot, Pseudomonas cichorii (Swingle) Stapp. Forty-one and 44% of female and male leafminer adults exposed for 18 h to *P. cichorii* on agar acquired the bacterium and transmitted it to clean chrysanthemums. When leafminer adults were exposed to *P. cichorii*-infected chrysanthemums and then transferred to agar plates, *P. cichorii* colonies (range 1–17 for 10 tests) were consistently detected on agar. Adults newly emerged from plants infected by *P. cichorii* during the larval stage of the insect had acquired the bacterium and transferred it onto agar in jars at a 16% success rate.

Resistance to pyrazophos in chrysanthemum leafminer. A greenhouse-collected strain of chrysanthemum leafminer tested as larvae in chrysanthemums showed ca. 150-fold resistance to pyrazophos. Tests of several types of organophosphorus insecticides indicated cross-resistance to a closely related compound, triazophos.

Diseases

Symptoms of tomato spotted wilt virus (TSWV) in ornamentals. An undescribed ringspot disease of *Cyclamen persicum*, cineraria, and calceolaria in six Ontario greenhouses in 1985 and 1986 was caused by the TSWV–western flower thrips complex. TSWV was isolated from only about 25% of diseased cyclamen, but immunosorbent electron microscopy and histological studies established an association with the disease, and the virus was transmitted to healthy cyclamens by grafts, mechanical inoculations, and inoculation by thrips. Typical symptoms took 3–4 months to appear at 13°C and were suppressed at higher temperatures. Mechanical transmission of the virus from cyclamen was greatly enhanced by low-temperature extraction. A highly specific high titre polyclonal antiserum has been produced against TSWV.

Virus diseases of orchids. A severe yellowing disease, epidemic in *Phalaenopsis* orchids in the past 2 years, has been associated with TSWV, transmitted by the western flower thrips and through vegetative propagation. Over 40% of all orchids grown both commercially and by hobbyists are infected with odontoglossum ringspot or cymbidium mosaic virus, or both. Both viruses are transmitted only through vegetative propagation. A bivalent antiserum has been developed, and several serological procedures have been evaluated for detecting these viruses.

Fusarium resistance to benomyl. Greater than 100-fold levels of resistance to benomyl were found in isolates of *Fusarium oxysporum* and *F. solani* from infected floricultural crops. Over 18% of *F. oxysporum* isolates and greater than 73% of *F. solani* isolates were somewhat resistant. Resistant (R) isolates of either species grew faster and germ tubes elongated faster than did sensitive (S) isolates on media amended with benomyl at 10 mg/L. The R isolates of both species grew less than the S isolates in the absence of fungicide on media. S and R groups of *F. oxysporum* showed similar spore germination. With *F. solani*, however, the fungicide stimulated germination of R isolates. The resistance was stable over 2 years of serial transfers.

Diseases of woody ornamentals–ash yellows. Ash yellows, a mycoplasmal disease of white ash, *Fraxinus americana*, and green ash, *F. pennsylvanica*, is responsible for ash dieback in Ontario. Symptoms include progressive loss of vigor and apical dominance, epicormic sprouts and brooms, precocious growth in the spring, and subnormal winterhardiness with frost damage to the cambium at ground level. DNA-specific fluorochromes and epifluorescence microscopy were used to identify infected sieve tube elements in roots of declining trees. This yellows disease was identified from Windsor east through the Niagara Peninsula and in isolated areas on the north shore of Lake Ontario. However, in some areas of declining white ash, yellows did not seem to be involved.

SMITHFIELD EXPERIMENTAL FARM

Tomato product consistency: Its measurement and influencing factors. The most reliable methods for measuring the consistency of tomato thin pulp and puree were the Bostwick Consistometer and the Ottawa Texture Measuring System using the back-extrusion cell and maximum force value (OTMS). The OTMS can provide additional information such as graininess but at greater cost and complexity than the Bostwick. Bostwick values correlated well with sensory perception of consistency; this instrument is inexpensive and simple to operate. Product consistency is associated with water-insoluble solids content and serum viscosity, both derived from the cell walls of the fruit. Levels of these properties differ characteristically from one cultivar to another. Cultivars also differ in apparent loss of water-insoluble solids and serum viscosity during concentration.

Herbicides on processing peas. In 1986 and 1987 a new herbicide, FMC 57020, looked promising as a preplant incorporated treatment. Highest yield in 1987 was with cyanazine at 1.5 kg/ha, applied preemergence. Other treatments giving good weed control and acceptable yields were bentazon plus Assist, FMC 57020, and trifluralin followed by MCPA-MCPB (the standard treatment). Mustard and ragweed, the most difficult weeds to control, were present in larger numbers in the weedy check, bentazon plus Assist plots, and trifluralin plus MCPA or MCPA–MCPB treatments.

Frosthardiness of apple fruit buds. Apple cultivars differed in bud hardiness during 1986 spring frosts at the 13-mm green stage (–4.5°C) and at the pink stage (–4.0°C). Blossom kill was 4% for Idared, 36% for Northern Spy and McIntosh, and 34% for Delicious flower buds during the first frost. Idared had 76% flower injury during the second frost, McIntosh and Northern Spy 73%, and Delicious 89%. In a comparison of early maturing cultivars, Jonamac had less frost injury than Jerseymac, Vista Bella, or Paulared.

Susceptibility of apple cultivars to cedar-apple rust and quince rust. In 1985 and 1986, the fruits of McIntosh, Delicious, Empire, Paulared, and Spartan were resistant to cedar-apple rust; however all except Spartan were susceptible to quince rust. Mutsu, Smoothee Golden Delicious, and Gloster 69 were very susceptible to both rust diseases. Northern Spy was susceptible to quince rust, and Idared was susceptible to cedar-apple rust. The scab-resistant cultivars Sir Prize, Prima, and Jonafree were susceptible to both rust diseases; Macfree, Moira, Murray, Novamac, Priscilla, and Redfree were susceptible to quince rust.

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Central Region
Région centrale

J.J. Cartier

P.B. Marriage

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PREFACE

The Central Region, located at the Central Experimental Farm in Ottawa, consists of the Animal Research Centre (ARC), Biosystematics Research Centre (BRC), Engineering and Statistical Research Centre (ESRC), Food Research Centre (FRC), Land Resource Research Centre (LRRC), and Plant Research Centre (PRC). In 1987, the programs were conducted by a complement of 970 person-years involving 280 professional staff. All the centres combine active research on national programs with recognition of regional requirements, linkage to other regional establishments, and service to the agri-food sector in specialized areas of their research, including collaborative ventures with industry, provinces, and universities. Significant research accomplishments are highlighted in the reports of the individual centres.

The Animal Research Centre conducts research in nutrition, physiology, management, breeding, product quality, disease resistance, and genetics in beef and dairy cattle, swine, poultry, and sheep; animal waste management; food and feed safety; and animal behavior. The centre strives mainly toward improving the production efficiency of intensively housed and managed livestock and poultry. Increased emphasis is placed on the introduction of the most up-to-date biotechnology methods to animal research. Mycotoxin research is providing sound guidelines on contamination tolerance in feeds.

The Biosystematics Research Centre provides Agriculture Canada and other departments, agencies, and their clients with a unique centre of systematic expertise for dealing with economic and social problems relating to insects, mites, spiders, plant parasitic nematodes, weeds, crop plants, native plants, plant parasitic and biodegrading fungi, and nonmedical bacteria. As the only Canadian organization with comprehensive collections, systematic research, and identification expertise, BRC continues to provide all systematic services to support production and resource protection for two major Canadian industries, agriculture and forestry. Research activities have been progressively realigned in response to demands in areas such as integrated pest management, environmental protection, and biotechnology.

The Engineering and Statistical Research Centre provides the Research Branch with a centre of expertise where engineers and statisticians carry out research and analyses to improve agricultural and food production and inspection systems and to support research by other disciplines.

The Food Research Centre provides assistance to the food sector in terms of increased quality, efficiency, productivity, and competitiveness through research programs covering the broad areas of dairy products processing; cereals and oilseeds processing; meat and poultry products; food composition and structure; sensory evaluation of foods; and nutrition and safety.

The activities of the Land Resource Research Centre include research, development, and services related to Canada's land resources. The centre provides leadership and is responsible for the following national programs: soil inventory, Canada soil inventory system, soil taxonomy and interpretation, soil degradation, land evaluation, crop information systems, and agroclimatic resources.

The Plant Research Centre has the mandate to develop, evaluate, and apply knowledge and technologies for crop improvement, crop protection, and plant health by integrating new biotechnological methods with conventional research approaches. PRC develops and releases elite genetic material and cultivars of cereals, oilseeds, and forage crops and determines methods for pest management and increased resistance to stress. Programs in biotechnology generate knowledge and technologies for the characterization and manipulation at the cellular and molecular levels of agronomically important traits in crop plants. An understanding is being gained of important plant–microbe interactions, and determinants for plant growth enhancement and disease resistance are being elucidated. PRC houses the central office for the Plant Gene Resources of Canada and is also responsible for the management of the Central Experimental Farm.

Further information about our programs may be obtained by writing to the research establishments concerned or by addressing inquiries to the Central Region, Research Branch, Agriculture Canada, Room 705, Sir John Carling Building, Ottawa, Ont. K1A 0C5; Tel. (613) 995-7084.

J.J. Cartier
Director General

PRÉFACE

La Direction de la Région centrale, située à la Ferme expérimentale centrale à Ottawa, comprend le Centre de recherches zootechniques (CRZ), le Centre de recherches biosystématiques (CRB), le Centre de recherches techniques et de statistiques (CRTS), le Centre de recherches sur les aliments (CRA), le Centre de recherches sur les terres (CRT) et, enfin, le Centre de recherches phytotechniques (CRP). En 1987, la Direction a géré des effectifs de 970 années-personnes dont 280 professionnels. Tous les centres allient la recherche active dans le cadre des programmes nationaux aux besoins en recherches des régions et du secteur agro-alimentaire, et établissent des liens contractuels avec l'industrie, les provinces et les universités. Chaque centre souligne ses plus importantes réalisations dans son rapport annuel.

Au Centre de recherches zootechniques, les chercheurs axent leurs travaux sur la nutrition, la physiologie, les pratiques d'élevage, la reproduction, la qualité du produit, la résistance aux maladies et la génétique appliquée aux bovins de boucherie, aux bovins laitiers, aux porcs, à la volaille et aux ovins; les recherches portent également sur le traitement des déchets animaux, l'innocuité des aliments et des moulées et le comportement des animaux. Le Centre vise surtout à accroître la productivité des bestiaux et de la volaille en élevage intensif. On met surtout l'accent sur l'application des méthodes biotechnologiques les plus perfectionnées à la recherche animale. Les travaux sur les mycotoxines permettent d'établir des lignes directrices claires sur les seuils de tolérance concernant la contamination des aliments pour bestiaux.

Le Centre de recherches biosystématiques offre à Agriculture Canada et à d'autres ministères et organismes, ainsi qu'à leurs clients un centre unique d'expertise où l'on résoud les problèmes socio-économiques causés par les insectes, les acariens, les araignées, les nématodes parasites des végétaux, les mauvaises herbes, les plantes cultivées, les plantes indigènes, les champignons parasites des plantes et biodégradants et les bactéries dépourvues d'intérêt médical. Grâce à ces collections complètes, à son service d'identification et à sa capacité de recherches systématiques, le CRB peut dispenser aux deux grands secteurs canadiens que sont l'agriculture et les forêts, tous les services nécessaires à la production et à la protection des ressources. Face à la demande, il a progressivement réorienté ses travaux dans les domaines de la lutte anti-parasitaire intégrée, de la protection de l'environnement et de la biotechnologie.

Pour sa part, le CRTS dispense à la Direction générale des services d'experts-conseils; ses ingénieurs et ses statisticiens mènent des recherches et des analyses pour améliorer la production agro-alimentaire et le système d'inspection et pour appuyer des travaux dans d'autres domaines.

Le Centre de recherches sur les aliments s'intéresse surtout à l'amélioration de la qualité, de l'efficacité, de la productivité et des facteurs compétitifs dans le cadre d'un programme laitier d'envergure; il étudie également la transformation des céréales et des plantes oléagineuses, les produits des viandes et des volailles, la composition et les caractéristiques des constituants des aliments, et la nutrition en général.

Le Centre de recherches sur les terres (CRT) s'occupe de recherche et de développement et offre des services liés aux ressources en terres du Canada. Il joue un rôle-clé et assume la mise en oeuvre des programmes nationaux dans les domaines de la prospection pédologique, du système canadien d'inventaire des sols, de la classification, de l'analyse et de la dégradation des sols, de l'évaluation des terres, du système d'information sur les cultures et des ressources agro-climatiques.

Le Centre de recherches phytotechniques a pour mandat de développer, d'évaluer et d'appliquer les connaissances techniques à l'amélioration et à la défense des plantes cultivées en intégrant les techniques de biotechnologie aux méthodes plus conventionnelles. Le CRP produit des lignées nouvelles et des cultivars de céréales, de plantes oléagineuses et fourragères et applique les méthodes de lutte intégrée aux facteurs de résistance au stress. Les programmes de biotechnologie visent à améliorer les caractéristiques génétiques et moléculaires des plantes. Les chercheurs du Centre étudient davantage les relations d'interactions plantes–microbes, les facteurs de croissance et de résistance aux maladies. Le CRP comprend également le Bureau des ressources phytogénétiques du Canada. C'est aussi le centre d'administration de la Ferme expérimentale centrale.

Pour obtenir de plus amples renseignements sur nos programmes, il faut écrire aux établissements de recherches concernés ou adresser les demandes à la Direction des priorités et des stratégies, Direction générale de la recherche, Édifice Sir John Carling, Pièce 709, Ferme expérimentale centrale, Ottawa, (Ont.) K1A 0C5; Tél. (613) 995-7084.

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A.J. Hackett, D.V.M., M.Sc., Ph.D.	Embryo transfer, female reproductive physiology
G.J. Marcus, B.A., Ph.D.	Reproductive physiology, embryo manipulation
J. Nagai,[7] B.Sc., D.Agr.	Embryo manipulation, quantitative genetics
M.P. Sabour, B.Sc., Ph.D.	Molecular and cellular genetics
R.M. Teather, B.Sc., Ph.D.	Molecular biology and genetic manipulation of rumen bacteria

Animal Waste Utilization

N.K. Patni, B.Ch.E., M.Sc., Ph.D.	Program Chairperson; Livestock waste utilization, farm pollution abatement

Dairy and Beef Cattle Nutrition

M. Ivan, Ing., M.Sc., Ph.D.	Program Chairperson; Nutrition and metabolism of trace minerals
A.S. Atwal, B.Sc., M.Sc., Ph.D.	Forage evaluation and nutrition
J.D. Erfle, B.S.A., M.Sc., Ph.D.	Rumen metabolism and nutrition

M. Hidiroglou, D.V.M., Dip. Nutr.	Vitamin and trace mineral nutrition
K.J. Jenkins, B.S.A., M.Sc., Ph.D.	Calf nutrition
J.R. Lessard,[8] B.A., B.S.A., M.S., Ph.D.	Forage conservation and nutrition
S. Mahadevan, B.Sc., M.Sc., Ph.D.	Rumen metabolism and nutrition
F.D. Sauer, D.V.M., M.S., Ph.D.	Rumen metabolism and nutrition
D.M. Veira, B.Sc., M.Sc., Ph.D.	Ruminant nutrition

Dairy Cattle Breeding and Production

A.J. Lee, B.Sc.(Agr.), Ph.D.	Program Chairperson; Dairy cattle breeding and production – statistical methodology and breeding strategies
T.R. Batra, B.V.Sc., M.V.Sc., M.S., Ph.D.	Dairy cattle breeding – field data analyses, disease resistance
C.Y. Lin, B.S., M.S., Ph.D.	Dairy cattle breeding – multi-trait mixed model sire and cow evaluation methods; Computer modeling
A.J. McAllister, B.S., M.S., Ph.D.	Dairy cattle breeding and production – selection for lifetime performance and use of crossbreeding

Swine Production

D.W. Friend, B.Sc., M.Sc., Ph.D.	Program Chairperson; Sow and piglet production, mycotoxins
A. Fortin, B.Sc.(Agr.), Ph.D.	Carcass composition, quality – swine, poultry, sheep, cattle
D.G. Fraser, B.A., Ph.D.	Animal behavior – swine, sheep, cattle

Poultry Breeding

A.A. Grunder, B.S.A., M.Sc., Ph.D.	Program Chairperson; Eggshell quality genetics, broiler breeding, goose breeding and management
J.R. Chambers, B.Sc., M.Sc., Ph.D.	Broiler breeding and management
R.W. Fairfull, B.Sc., M.Sc., Ph.D.	Egg stock breeding and management
C.P.W. Tsang, B.Sc., M.Sc., Ph.D.	Physiology – eggshell quality and egg production

Poultry Nutrition

I.R. Sibbald, B.Sc.(Agr.), M.Sc., Ph.D., D.Sc.	Program Chairperson; Nutrient requirements and feedingstuff evaluation
N.A.G. Cave, B.Sc., M.Sc., Ph.D.	Broiler breeder nutrition and management, evaluation of novel feedingstuffs
R.M.G. Hamilton, B.Sc.(Agr.), M.Sc., Ph.D.	Nutrition and physiology – minerals, mycotoxins

Sheep Production

L. Ainsworth, B.Sc., M.Sc., Ph.D.	Program Chairperson; Female reproductive physiology
D.P. Heaney, B.S., M.S., Ph.D.	Nutrition and intensive management
G.A. Langford, B.Sc., M.Sc., Ph.D.	Male reproductive physiology
J.N.B. Shrestha,[9] B.V.Sc.A.H., M.S., Ph.D.	Breeding and intensive production – applied quantitative genetics

Animal Feed Safety and Nutrition

H.L. Trenholm, B.Sc.(Agr.), Ph.D.	Program Chairperson; Mycotoxins, toxicology
M.H. Akhtar, B.Sc., M.Sc., Ph.D.	Pesticide metabolism and residues
L.M. Coté,[10] B.Sc., M.Sc., Ph.D.	Biochemical toxicology, mycotoxins
E.R. Farnworth, B.Sc., M.Sc., Ph.D.	Lipid nutrition and perinatal metabolism
J.K.G. Kramer, B.Sc., M.Sc., Ph.D.	Lipid chemistry and biochemistry
D.B. Prelusky, B.Sc.(Pharm.), Ph.D.	Mycotoxin metabolism, toxicology

Departures

D. Campbell[3,4]	Programmer – Analyst
R.S. Gowe,[11] B.S.A., M.S., Ph.D., F.P.S.A.	Egg stock breeding and management
H.M. Mucha[3,4]	Programmer – Analyst

VISITING SCIENTISTS

R.R. Asmundson, B.Sc., Ph.D. Department of Scientific and Industrial Research, Government of New Zealand, Palmerston North, New Zealand	Molecular biology of cellulolytic rumen bacteria
M.L. Biehl, D.V.M. Department of Veterinary and Biological Sciences, University of Illinois, Urbana, Ill.	Mycotoxin metabolism
W.B. Buck, B.S., D.V.M., M.S. National Animal Poison Control Centre, University of Illinois, Urbana, Ill.	Mycotoxins and veterinary toxicology
M. Kimura, Ph.D. Faculty of Agriculture, Gifu University, Gifu, Japan	Polymorphisms of hemoglobin in poultry
W. Tang, Ph.D. Hunan Agricultural College, Changsha, People's Republic of China	Feed evaluation bioassays

Natural Sciences and Engineering Research Council (Can.) postdoctorate fellows

C.L. Boogaard, B.A., M.Sc., Ph.D., 1986–1987	Molecular genetics – analysis of casein genes
E. Charmley, B.Sc., Ph.D., 1987–1988	Forage evaluation
L.L. Charmley, B.Sc., Ph.D., 1985–1987	Copper metabolism
G. Davis, B.Sc., Ph.D., 1986–1988	Mouse embryo transfer, transgenic mice
D. Denicourt, B.Sc., M.Sc., Ph.D., 1987–1988	Molecular genetics – analysis of casein genes
S.N. Liss, B.Sc., M.Sc., Ph.D., 1987–1989	Molecular biology of rumen bacteria
J.F. Patience, B.Sc.(Agr.), M.Sc., Ph.D., 1985–1987	Swine nutrition and metabolism – acid–base homeostasis
B. Pawluczuk, B.Sc., M.Sc., Ph.D., 1985–1987	Carcass quality measurement and artificial insemination in geese
J.P. Rushen, B.Sc., Ph.D., 1985–1987	Behavior of swine and sheep in intensive husbandry systems

Canadian International Development Agency (CIDA) trainees (Canada–Brazil Project)

L. Aroeira, M.Sc., Ph.D. National Dairy Cattle Research Centre (CNPGL), Coronel Pacheco, Brazil	Dairy cattle nutrition
H.C.V. Codagnone, M.Sc. Parana State Agricultural Research Institute (IAPAR), Londrina, Brazil	Dairy cattle nutrition
M.S. Dayrell, B.Sc., D.Sc. National Dairy Cattle Research Centre (CNPGL), Coronel Pacheco, Brazil	Ruminant mineral nutrition
M.L. Martinez, B.S., M.S., Ph.D. National Dairy Cattle Research Centre (CNPGL), Coronel Pacheco, Brazil	Dairy cattle breeding and selection
D. Perotto, M.Sc. Parana State Agricultural Research Institute (IAPAR), Londrina, Brazil	Dairy cattle breeding and selection
J.K. Tahira, B.Sc., M.Sc. Parana State Agricultural Research Institute (IAPAR), Londrina, Brazil	Dairy cattle reproduction
M.A.M. Vetromila, M.Sc. National Dairy Cattle Research Centre (CNPGL), Coronel Pacheco, Brazil	Dairy cattle reproductive physiology

Agriculture Canada research contract

J.E. Irwin, B.Sc., Ph.D.	Gene cloning in rumen bacteria

New Brunswick Milk Marketing Board–Hoffman-La Roche Ltd. research contract

B. Fryzuk, B.Sc.	Vitamin E and mineral analysis of milk

Graduate students

J. Castanon, B.Sc.	Feed evaluation bioassays
H.C. Gauvreau, D.V.M.	Vomitoxin metabolism
H.V. Petit, Bacc., M.Sc.	Calf nutrition
W.J. Zhang, B.Sc.	Feed evaluation bioassays

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[1] Appointed 1 April 1987.

[2] Acting Director, 1 January 1987 to 31 March 1987. Seconded to Livestock and Poultry Division, Food Production and Inspection Branch, 4 May 1987 to 31 December 1987.

[3] Seconded from Systems and Consulting Directorate, Corporate Management Branch, until 31 March 1987.

[4] Transferred to Animal Research Centre staff, 1 April 1987.

[5] Seconded from Libraries Division, Corporate Management Branch.

[6] On transfer of work at Molecular Genetics Laboratory, National Research Council of Canada, Ottawa, Ont., 6 April 1987 to 31 March 1988.

[7] Acting Program Chairman, 6 April 1987 to 31 March 1988.

[8] Seconded to Headquarters, Research Branch, since 1 November 1981.

[9] On transfer of work at Department of Animal Science, Cornell University, Ithaca, N.Y., 1 November 1986 to 31 October 1987.

[10] On extended leave at the University of Illinois, Urbana, Ill., from 7 March 1987.

[11] Resigned status as honorary research associate, 15 December 1987.

INTRODUCTION

As a national centre for animal research, the role of the Animal Research Centre is to identify, define, and solve the numerous problems associated with improving the production efficiency of livestock and poultry in Canada. Associated responsibilities include research on the humane care of farm animals and on product quality and feed safety to improve the marketability of Canadian agricultural products. ARC has nine multidisciplinary program teams consisting of researchers with a broad range of scientific knowledge. Both applied and basic studies are under way.

ARC is a centre of expertise in the area of animal biotechnology, which includes the fields of genetic engineering, embryo manipulation, and molecular genetics. Other important research areas include animal waste utilization and management; reproductive physiology; trace mineral and vitamin requirements; dietary utilization of fats and oils; pesticide metabolism and residues; animal behavior in intensive production systems; carcass evaluation; ruminant digestive physiology; and the effects and metabolism of toxic contaminants in animal feeds. Programs also include research on nutrition of dairy and beef cattle, swine, poultry, and sheep. Major breeding projects in dairy cattle have been terminated, and sheep production research will be completed by 1990. The future direction of all programs is being evaluated with the objective of restructuring the centre and redirecting resources to new program areas. Increased collaboration with and support by industry is being achieved.

The effective transfer of research findings from the laboratory to the agri-food industry continues as a major priority. A significant contribution for 1987 was the technical bulletin *Research and technology for increasing the efficiency and output of lamb production systems*. Research data was published in 67 scientific and 57 technical and popular press articles. Among the many visitors to ARC and the Greenbelt Research Farm, the centre was especially honored by the House of Commons Standing Committee on Agriculture, the ministers of Agriculture from Uruguay and Honduras, government officials from Bulgaria, agricultural missions from Turkey and the People's Republic of China, the directors of agricultural research from Pakistan and Poland, as well as numerous Canadian and international scientists, extension workers, administrators, and livestock and poultry producers.

ARC continued participation in cooperative research and development programs in Brazil and Cuba in the areas of dairy cattle and poultry breeding and dairy cattle production. In the major project with the Dairy Research Centre of the Brazilian National Agricultural Research Organization and its state counterpart in Parana, a further seven researchers spent 1–4 months with ARC dairy and beef nutritionists, physiologists, and geneticists. At the request of the Ministry of Agriculture and Fisheries, Dr. Ivan visited the Sultanate of Oman to consult on Omani problems of mineral metabolism and copper availability in ruminants.

Five ARC scientists received major national or international awards in recognition of the research excellence at the centre. Dr. Sibbald received the Government of Canada's prestigious Merit Award for his outstanding contribution to the field of poultry feedstuff evaluation and energy metabolism. He is the sixth ARC recipient in 7 years to be honored by this award. The Canadian Society of Animal Science presented Dr. Jenkins with its Certificate of Merit for his work in the area of calf nutrition. The society also recognized Dr. Nagai in presenting him with the Canadian Association of Animal Breeders Award of Excellence in Genetics and Physiology. Dr. Nagai's work in quantitative genetics using mice as pilot animals has provided new breeding strategies for obtaining maximum genetic improvements in livestock. At an International Congress of Meat Science and Technology held in Helsinki, Finland, Dr. Fortin's presentation entitled *Objective detection of PSE–DFD pork using electronic grading probes* was honored as Best Research Paper in the analytical methods session. A major traveling fellowship was granted to Dr. Gavora by the Japan Society for the Promotion of Science. The fellowship recognizes his leadership in the field of genetics of disease resistance and provides for a term of research study at a Japanese research establishment.

In line with departmental and branch research goals, the ARC biotechnology program was strengthened by Dr. Fiser's transfer to it from the sheep production program. Work in the area of cryopreservation of gametes will be expanded as Dr. Fiser initiates studies on swine semen and embryo freezing. The final phase of the national cooperative dairy cattle breeding project was reached. Experimental work at the four cooperating Research Branch stations has been completed, and the ARC dairy herd has been reduced as the last scheduled calvings and production data are obtained. As they become available, cattle are being utilized for embryo manipulation studies by the biotechnology program.

This annual review highlights research for 1987. Some studies that have produced particularly noteworthy results include the following: 13 synthetic genes have now been designed to modify the amino acid composition of rumen bacteria for ruminants; methodology has been tested to detect casein genotypes at the DNA level that may permit the typing of bulls and heifers for potential production at a young age; bovine embryos were microsurgically split and implanted into recipients that successfully delivered single and twin calves; a nucleus-specific staining technique was developed to monitor sperm survival and membrane damage during cryopreservation; a well-balanced dairy cattle diet of corn silage, alfalfa silage, and concentrate was found not to require supplemental field-dried hay to sustain good milk production; the beneficial effects of monensin to reduce ketosis were demonstrated; basic data on an enzyme of rumen bacteria that degrades dietary amino acids have been determined so that this breakdown process can be controlled and better ruminant nutrition can be achieved; studies of the effects of iron in milk replacer diets for calves indicated that excess supplementation is ineffective and does not improve performance; statistical methodology has been developed to allow better evaluation of lifetime performance in dairy cattle; early breeding of dairy heifers was shown to be a practical approach for improving productivity; further research has confirmed the value and high potential of naked oats as a dietary ingredient for swine and poultry; the importance of monitoring early weight gain in piglets was demonstrated as an indicator of subsequent performance; data on hog carcasses have provided more accurate estimates of carcass quality and were the basis for a revision of the Canadian grading standard; summaries of five generations of selection in broilers have shown significant improvements in a number of important traits including body weight, feed efficiency, and leanness; the important effects of the microenvironment on poultry production must be accounted for in an analysis of research data; the possible role of endogenous viruses in the prevalence of birds that test positive for avian lymphoid leukosis has been discovered and may explain the difficulty in eradicating this disease by conventional means; a simple test was developed to provide a biophysical index of concentration and maturity of goose spermatozoa; the heritability of various important traits in geese has been evaluated; a hormonal form of vitamin D has beneficial effects on egg quality during the later stages of the production cycle; the inheritance of immunity and other production traits in the synthetic strains of sheep developed at ARC has been assessed; simple procedures such as roasting or the addition of bisulfate diminished the effects of mycotoxins in contaminated diets for swine; studies with mycotoxins have been extended to poultry where toxic residues quickly declined once contaminated food was withdrawn; pesticide residue research using fenvalerate and *m*-phenoxybenzaldehyde established metabolic pathways for these two important insecticides; three new sheep breeds are being registered as the by-product of selection of these highly prolific and productive strains.

Detailed information on the research accomplishments, methodology, and results can be obtained from the publications listed at the end of this report. Reprints of these publications and copies of this report are available on request from the Animal Research Centre, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6; Tel. (613) 993-6002.

E.E. Lister
Director

BIOTECHNOLOGY

Genetic manipulation of rumen bacteria

Rumen bacteria are being genetically engineered to improve the efficiency of feed utilization by ruminants. Characterization of a (1→3)(1→4)-β-D-glucanase from *Bacteroides succinogenes* cloned in *Escherichia coli* has been completed. The cloned bacteria gene will provide a readily identifiable marker for future experiments.

New gene banks have been prepared in *E. coli* from the dominant rumen bacteria *Selenomonas ruminantium*, *Lachnospira* *multiparus*, and *Bacteroides succinogenes*, and clones producing β-glucosidases have been isolated. The isolation and analysis of these genes provide information about, and tools to modify, the regulation of cellulase gene expression. This information is useful to industries involved in the utilization of cellulose and related plant polysaccharides. Polysaccharide degrading enzymes, isolated by DNA cloning from rumen bacteria, produce enzymes of very high specificity at low cost. These have a number of commercial and industrial applications.

A preliminary survey of the antibiotic spectrum of a polysaccharide-linked amino phenol present in seed coats has suggested that this compound may inhibit the growth of cellulose degrading bacteria in the rumen.

Thirteen new synthetic genes, designed to modify the amino acid composition of rumen bacteria, have been cloned in *E. coli*, and their effect on the host cell has been determined. Bacteria provide the major part of the dietary protein requirements of the ruminant, and the new bacteria are expected to be better able to meet the specific dietary amino acid requirements of high-producing dairy cattle.

Animal molecular genetics

Poultry. Lymphoid leukosis is a lymphoproliferative disease of chickens, caused by a retrovirus. Although mortality from the disease is generally low, subclinical infections with lymphoid leukosis virus (LLV) have significant negative effects on productivity and cause increased mortality from causes other than lymphoid leukosis. Resistance to LLV infection is inherited. A viral glycoprotein and a genetically controlled cell receptor are involved in viral penetration into host cells. In collaboration with the Animal Diseases Research Institute (ADRI), biochemical and immunological methods are being used to identify the cellular receptor that causes susceptibility. Isotope analysis of labeled chick embryonic fibroblast surface proteins from susceptible cells has been completed. LLV particles revealed three protein bands of apparent molecular weight of 72, 40, and 37 kD. The association of these proteins with viral receptor is being investigated.

In addition to the exogenous lymphoid leukosis retroviruses, there is a subgroup of related viruses that are produced by the chicken itself from endogenous viral (*ev*) genes that are a permanent component of the genome. A total of 23 *ev* loci have been identified that range in expression from silent ones that produce no gene product to genes that produce the complete endogenous virus. The *ev* genes affect resistance to exogenous LLV and may also influence the bird's performance. In a collaborative project with the poultry industry, Macdonald College, the Animal Diseases Research Insitute and the United States Department of Agriculture, two strains of White Leghorns that were housed at ARC and were free of the exogenous virus were studied. The strain selected for high egg production, egg weight, and resistance to Marek's disease tended to have fewer *ev* genes with a lower level of expression than the related strain selected for susceptibility to Marek's disease. The presence of the *ev* genes, particularly those with a higher level of expression, tended to be associated with reduced egg production and egg weight. An inbred ARC line, which was developed by selection for high egg production and resistance to Marek's disease was completely free of *ev* genes and will be useful for future experiments.

Dairy cattle. Some milk protein genotypes are associated with increased production of milk or cheese-making qualities. κ-Casein cDNA probes and DNA restriction fragment length polymorphism (RFLP) were used to determine allelic variation at the κ-casein locus. Allelic variation was identified, which was not detected at the protein level. Casein cDNA sequences are now being used to isolate and clone genomic sequences from a bovine genomic library. These will be used as DNA probes to identify RFLPs for assessment of genomic variability in ARC herds. The method allows the detection of the κ-casein genotype at the DNA level, thus permitting the typing of bulls and heifers for selection purposes.

Transgenics. Animals with a DNA recombinant gene (transgene) are unique with regard to the site of integration and copy number in the host genome. The fate of a transgene over generations and as the expression of the gene needs to be investigated, because transgenic livestock is expected to be widely available in the near future.

In an experiment, male mice with the rat growth hormone gene fused with the metallothionein promoter were mated with females of three lines selected for milk production and adult weight. In two-way crosses, adult weight of the progeny from the mating to males with the growth hormone gene was 16% heavier than that from the mating to males without the gene. In two-way crosses and backcrosses, the gene was transmitted, but the effect of the gene on adult weight was not as obvious in backcrosses as in two-way crosses.

Reproductive process control

Embryos. Embryos from outstanding cows that have been mated to superior bulls can be used for rapid genetic improvement of cattle. The various procedures of embryo manipulation are useful tools for producing a large number of superior genetically identical animals (clones).

Using a commercial preparation of follicle stimulating hormone (FSH), superovulation was achieved in 71% of 192 treated cows. Of the cows responding to treatment, embryos were collected from 81%, with an average recovery of 4.1 embryos per cow. The FSH had been injected twice a day over 4 days at 40 mg in eight equal doses or in varying doses of 6.5 and 6.5, 5.5 and 5.5, 4.5 and 4.5, and 3.5 and 3.5 mg. The number of cows responding and the number of embryos collected were similar in both regimes. Using the former regime, less labor was required and treatments were more accurate. FSH from a new Canadian source was compared to that previously used for superovulation. The results were similar.

Seventy-five cows that were observed and confirmed in estrus were used as recipients of fresh embryos at the morula or blastocyst stage. Pregnancy was confirmed in 22 cows (30%). Eleven embryos were bisected microsurgically and transferred. Three of the split pairs were impregnated successfully, with a set of identical male twins born to one recipient and single heifers born to the other two. Cows that received prostaglandin $F_{2\alpha}$ for use as recipients and did not respond to this treatment or that failed to maintain a pregnancy were monitored carefully for estrus and subsequently were inseminated. Over 80% were successfully bred artificially and remained in the herd for later use as embryo recipients.

A system has been developed for obtaining unfertilized oocytes and embryos at an early stage of development (4–8 cell embryos), both of which are necessary for developing techniques of producing clone calves. Micromanipulation procedures for enucleation of the oocyte and insertion of a blastomere in place of the removed polar body beneath the zona pellucida have been developed. Whole 4–8 cell embryos were encapsulated in agar, placed in the ligated oviducts of sheep, and recovered after 4 days of in vivo culture. The embryos had developed normally to the morula–blastocyst stages, but recovery was critically dependent on the particular agar used, as some products were found to disintegrate in the oviduct, resulting in loss of the embryos.

Semen. To improve the fertility from the use of frozen boar semen, a cryobiological study was initiated to identify the optimum freeze–thaw conditions. Research on freezing rate–glycerol concentration interaction also is in progress. Survival, assessed as post-thaw motility percentage and as the percentage of spermatozoa with a normal apical acrosomal ridge, was influenced by glycerol concentration. Motility increased until the optimum glycerol concentration was reached, but acrosomal membranes showed increasing damage with glycerol concentrations above 2%.

To evaluate sperm survival and membrane damage a nucleus-specific staining procedure has been developed. The dye stained the nucleus of ram spermatozoa only when the plasma and acrosomal membranes were damaged.

ANIMAL WASTE UTILIZATION

Pesticide persistence and movement

Soil persistence of, and agricultural drainage water contamination by, metolachlor, cyanazine, and atrazine in predominantly clay loam, corn-cropped fields were studied in a collaborative project with the Ontario Ministry of Agriculture and Food. Soil persistence increased in the following order: cyanazine > metolachlor > atrazine. In the surface soil (0–7.5 cm deep) under cool humid conditions, metolachlor concentration decreased according to a first-order expression, with a half-life of 72 and 39 days for preplant incorporation and preemergent application, respectively. The presence of metolachlor, cyanazine, atrazine, and deethylated atrazine was detected in effluents from tiles that were 0.6–0.9 m deep but not in soil at depths greater than 0.3 m. Metolachlor concentrations ranged from not detectable (ND) to 12 μg/L in tile effluents and from ND to 1.5 μg/g (mean values) in soil.

Composting of liquid manures

The feasibility of composting manure slurries from dairy cattle, sheep, and poultry with sphagnum peat was studied in a collaborative project with the Land Resource Research Centre. Mixtures of slurry and peat were laid down as windrows over open-ended, perforated horizontal pipes that provided nonmechanical aeration. Thermophilic temperatures were attained in 1–3 days and maintained for 2–5 weeks without further mixing.

DAIRY AND BEEF CATTLE NUTRITION

Feeding cows in early lactation

Many dairy farmers prefer to feed some hay to milking cows. However, conservation of hay crops as silage is much less dependent on weather conditions than is field drying of hay. In an experiment with 36 milking cows, given a total mixed diet of corn silage, alfalfa silage treated with formic acid, and concentrate (25:25:50 dry-matter (DM) basis), at 4–15 weeks of lactation, supplemental feeding of 2.5 kg of alfalfa long-hay laced with 200 g of molasses either at 6:00 a.m. or 5:00 p.m. was shown to have no effect on average daily DM intake, milk yield, or milk-fat yield, which were 18.2–18.7 kg, 30.2–31.8 kg, and 1059–1079 g, respectively. Thus, it was concluded that there is no need to feed hay when good-quality silage is available.

By analyzing daily morning and evening milk samples for three 2-week periods, the fat content of milk was shown to be very variable, and the use of infrequent analyses for assessing the potential of individual cows could be misleading. For 39% of the cows tested, average variations in fat yield were more than 100 g/day when daily tests were compared with weekly tests; and the maximum fat variation was 340 g/day. However, when averaged for 36 cows, the difference for fat was negligible; therefore, analyses of bulk tank samples should be reliable.

Monensin (Mnn)

Mnn, a biologically active compound produced by a strain of *Streptomyces cinnamonensin*, is widely used as a feed additive for feedlot steers to improve efficiency of production. Its mode of action is both as a coccidiostat and a modifier of rumen fermentation, shifting volatile fatty acid production from acetate to propionate. In an experiment with 36 cows, Mnn was incorporated into dairy rations at 15 and 30 g/t of total diet (DM) and fed from 1 week prepartum to 3 weeks postpartum. The incidence of clinical and subclinical ketosis for the high and low Mnn levels compared with the controls was 8 and 33% versus 50%, respectively. Mean levels of β-hydroxybutyrate in blood declined from a control level of 7.2 mg.percent to 5.7 and 3.9 mg.percent for the low and high Mnn levels, respectively. Milk production for a 16-week period was 3344 kg (29.9 kg daily), 3675 kg (32.8), and 3516 kg (31.4) for the control, low, and high Mnn groups. Mnn raised milk lactose levels significantly. There were no adverse effects from Mnn, and cows completed lactation uneventfully. Subsequent breeding and pregnancies were not affected. At current costs, the use of Mnn as a ketosis preventative amounts to approximately $1.20 per cow per lactation.

Protected proteins and amino acids

A new process for protecting soybean meal against degradation in the rumen has been developed. The procedures have been modified, and conditions for pilot scale preparations have been established. The amount of residual formaldehyde has been reduced much below the accepted level in ruminant feed. Conditions have been determined so that soybean meal with protection ranging from 50 to 90% can be prepared. Other feed materials such as corn gluten meal were also found to be effective coating materials, thus reducing the cost of the process. The uniqueness of the process is that very high protection can be achieved without any loss of amino acids from the soybean meal. No known currently available procedure is capable of producing such a product.

Amino acid destruction

In ruminants, intact dietary protein becomes unavailable because microorganisms in the rumen degrade the proteins to amino acids, which are further broken down to NH_4 and CO_2. If amino acid destruction could be controlled, more of the dietary amino acids could be made available to the animal. Knowledge regarding the enzymatic processes involved in the destruction of amino acids by rumen microorganisms is limited. In continuing research, an enzyme that degrades threonine has been isolated from ***Megaspharea elsdenii***, and its properties were studied.

The enzyme has a molecular weight of 160 000 and consists of four subunits of 40 000. It has 4 mol of pyridoxal phosphate bound per mole; pH optimum is around 9.0; V_{max} is 1080 µmol of threonine degraded per minute per milligram of protein; k_m for threonine is 26.2 m*M*. The enzyme is four times more active on threonine than on serine; both amino acids are degraded by the same enzyme; no activity is found with DL-threonine, threonine amide, allo-threonine, and D-serine; no added cofactor requirements were found. The enzyme is inhibited by a number of metal ions, hydrazide, and KCN; by diphenyl iodonium bromide (58% at 1 m*M*), lasalocid, and monensin (70–90% at 0.5 m*M*); and by other amino acids such as leucine, isoleucine, and cysteine. Ammonia is not inhibitory.

Cellulolytic enzymes

A large number of enzymes in cellulolytic rumen bacteria are involved in fiber hydrolysis. Their properties are similar, and a successful approach to their study has been to clone the DNA for these enzymes into a host organism, such as *Escherichia coli*, and select clones that contain a single enzyme that can then be isolated and its properties verified without interference from other enzymes.

A (1→3)(1→4)-β-D-glucanase from *Bacteroides succinogenes* has been cloned in *E. coli*. The enzyme, which was purified 600-fold by ion exchange and hydroxylapatite chromatography, hydrolyzed lichenin and oat β-glucan [(1→3)(1→4) mixed linkage β-D-glucans] but not starch, carboxymethylcellulose, laminarin, or xylan. The enzyme has a temperature optimum at 50°C and a broad pH optimum with maximum activity at pH 6.0. The molecular weight of the enzyme was approximately 37 kD. The k_m for the purified enzyme was 0.35 and 0.71 mg/mL for lichenin and oat glucan, respectively. The major products of hydrolysis of the cloned enzyme on lichenin were a triose (82%) and a pentaose (9.5%). Major products of hydrolysis of oat β-glucan were tentatively identified as 3-*o*-β-cellobiosyl-D-glucose (64%) and 3-*o*-β-cellotriosyl-D-glucose (30%). It was concluded that the cloned enzyme has a mechanism and specificity for bond cleavage similar to that of the mixed linkage β-D-glucanase isolated from *Bacillus subtilis*.

The cloning of this mixed linkage β-glucanase in *E. coli* marked the first time that it was possible to show that *B. succinogenes* had a separate enzyme for hydrolysis of β(1→3)(1→4) mixed linkages. The similarity that was observed between the properties of the cloned enzyme and the (1→4)-β-D-glucanase present in *B. succinogenes* explains why these two activities had not been resolved previously.

The cloned enzyme has potential for use in the estimation of mixed linkage β-D-glucans in plant materials. In conjunction with a β-glucosidase the enzyme could also be used to make the glucose in mixed linkage β-D-glucans in oats and barley endosperm available to nonruminants.

Selenium (Se)

Intraruminal Se-glass boluses were administered to beef cows during the last trimester of pregnancy. Elevated whole blood concentrations of glutathione peroxidase, a Se-containing enzyme, were observed monthly for the next 10 months following initiation of treatment, reaching the maximum at the 4th month. Monthly milk samples also showed elevated Se concentrations. The boluses were highly effective in raising the Se status of progeny.

Kinetics of vitamin D

A study with wethers exposed to ultraviolet radiation (UVR) compared the kinetics of intravenously administered, tritium-labeled 25-hydroxyvitamin D_3 (25-OHD$_3$) to that of controls, which were nonradiated. Plasma 25-OHD$_3$ increased from 13 to 31 ng/mL by day 25 and then remained at a steady-state concentration until day 70. In wethers not exposed to UVR, plasma 25-OHD$_3$ averaged 13.2 ng/mL plasma and did not change over the course of the experiment. The results were analyzed by curve-fitting the data to a two-compartment pharmacokinetic mathematical model. The physiological half-life of tritiated 25-OHD$_3$ lasted approximately 390 h in both groups. In wethers exposed to UVR, the elimination and clearance rate of 25-OHD$_3$ were significantly greater than in controls. Increased pool size was observed in the irradiated wethers.

Copper (Cu)

In ruminants, Cu deficiency may be caused either by inadequate dietary intake or by reduced availability of ingested Cu. However, excess Cu results in liver accumulation, with consequent toxicity. Rumen ciliate protozoa were found previously to reduce the bioavailability of Cu by 37–50% in certain diets. However, it was not known if the magnitude of the reducing effect of protozoa depended on Cu concentration in the diet.

Biopsies were performed in 32 naturally fauna-free sheep to establish the initial Cu concentration in the liver. The sheep were then assigned to four groups. In two groups each animal was faunated by dosing with 250 mL of ruminal fluid taken from donor sheep with a mixed protozoa population. The other two groups remained fauna-free. A diet of corn silage and soybean meal containing a low or high Cu concentration (7 or 15 µg per gram of DM) was group-fed ad libitum for 197 days. At the end of the experiment, livers and ruminal contents were analyzed. Faunated sheep grew faster and consumed more feed and Cu than did the fauna-free rams but had the following: lower concentration of Cu in the liver; lower total amount of Cu in the liver per unit of Cu intake; and lower ruminal Cu solubility for both low and high Cu diets. The relative hepatic Cu uptake was higher for sheep fed the low Cu than the high Cu diet. The results showed a definite decreasing effect of faunation on the availability of dietary Cu. The magnitude of the effect was independent of the Cu concentration in the diet.

High levels of iron (Fe) in calf milk replacers

Calf milk replacers that are formulated mainly from milk products are deficient in Fe and are routinely supplemented with the element during their manufacture. Products fed for veal production have a relatively low Fe concentration. However, milk replacers fed to calves destined to be herd replacements or dairy beef can contain high Fe concentrations because of the low cost of Fe salts and a general belief that excess Fe is well tolerated.

A feeding experiment estimated the lowest amount of dietary Fe (as ferrous sulfate) that would reduce calf performance and feed utilization. For 6 weeks newborn male calves were fed milk replacer containing Fe at either 100 (control), 500, 1000, 2000, or 5000 ppm.

The calves tolerated all Fe treatments except 5000 ppm. The average daily gain (ADG) over 6 weeks for the first four treatments was 0.65 kg/day and feed conversion 1.5 kg of feed per kilogram of gain. At the Fe level of 5000 ppm there was a 6% feed refusal, 20% reduction of ADG, and 15% poorer feed efficiency. There were no other signs of Fe toxicity. All experimental calves appeared healthy throughout the trial, and no gross abnormalities were found at necropsy.

The amount of dietary Fe excreted in the feces was very high for all groups, ranging from 65% for 100 ppm to 84% for 5000 ppm. The main tissue responses to increased dietary Fe were seen in the liver and the spleen, each of which had an enormous Fe content, particularly the liver at the 5000 ppm level.

This study showed that up to 6 weeks of age calves can tolerate Fe up to 2000 ppm in milk replacer, but a level of 100 ppm was adequate for good performance and feed utilization. There appeared to be no benefit in feeding iron in excess of 100 ppm. Research has shown that excessive dietary Fe can be hazardous for baby pigs when the fat intake is high and vitamin E low. As these conditions also can occur for calf milk replacers, it may be worthwhile to avoid excessive Fe in preruminant calf diets.

DAIRY CATTLE BREEDING

National cooperative dairy cattle breeding project

Profitable performance in dairy cattle is influenced by reproduction and survival in addition to milk and milk component output. The contribution of genetic and management factors to these traits has been assessed in studies arising from the national cooperative dairy cattle breeding project. Crossbred heifers (Holstein–Ayrshire) had a higher probability of survival to initiation of second lactation than pureline Holsteins and had 21 weeks longer expected herd life than the average of the purelines. First- and second-generation crosses between the Holstein line and the Ayrshire-based line were equivalent to Holsteins for fat yield in the first three lactations. Important maternal line influences on milk and fat yield favored Ayrshire dams and partly offset the larger general breed advantage of the Holstein over the Ayrshire.

Computing variance components

Researchers have recently proposed an efficient algorithm for computing restricted maximum likelihood estimates of variance components in a class of mixed models. The procedure involves the application of Householder transformation to tridiagonalize the coefficient matrix of the mixed model equations, thus eliminating the need for direct matrix inversion. An ARC study has extended the computing algorithm and applied the singular value decomposition of the coefficient matrix such that restricted maximum likelihood estimation of variance components in a class of mixed models became a computational triviality and required little computer time during the process of iteration. The use of this computing approach provides a major saving in statistical analyses of animal research data to address complex questions. Results of such analyses are essential in estimating genetic parameters of the complex of traits contributing to lifetime performance and the design of breeding programs and strategies to breed cattle with maximum potential lifetime net return.

Effects of breeding age on lifetime performance

Production and reproductive performances in second and third lactations, and lifetime performance were compared between groups of dairy heifers bred at first heat after 350 days versus 462 days. Both groups were subject to similar feeding and management practices. Although the 462-day group had slightly better first-lactation performances than the 350-day group, these advantages were not carried over to second and third lactations. No significant differences existed in three-parity lifetime performance between the groups. However, when compared for performance to a maximum of 61 months of age, the 350-day group had a longer productive life (730 versus 623 days), produced greater lifetime milk (10 693 versus 9218 kg), and yielded more milk per day of herd life (6.8 versus 5.9 kg). One-month reduction in age at first calving would significantly increase total milk in three parities or to 61 months of age by 427 and 554 kg, respectively. The results suggested that early breeding is a practical approach to improving profitability for the dairy industry.

Bovine lymphocyte antigen (BoLA)

The study of BoLA is the first attempt to use direct analysis of genetic material at the gene level for the genetic improvement of dairy cattle in Canada. Blood samples from 179 Holstein cows were typed for 37 antigens, controlled by codominant alleles of the BoLA-A locus, to study the relationships of BoLA alleles with heifer body weights and measurements, reproduction, and production traits. Only 10 antigens were present, and there were differences in the frequencies of the 10 associated alleles. The most common allele was W10, which had an allelic frequency of 31.1%. Substitution of W20A for W10 significantly ($P < 0.05$) increased body weight at 350 days of age and at first calving by 29.6 and 61.5 kg, respectively. Substitution of W12.2 for W10 significantly ($P < 0.05$) decreased age at first observed heat by 57 days. Substitution of W6.1 for W10 allele significantly ($P < 0.05$) increased 308 days first-lactation milk and protein yield by 1401 kg and 49 kg, respectively. The effect of this gene substitution on fat percentage was -0.19%; however, this difference was not significant ($P > 0.05$).

SWINE PRODUCTION

Naked oats

Naked oats, *Avena nuda*, have strong potential as a feedstuff and are suitable for partial replacement of corn and soybean meal in diets for growing–finishing pigs. In previous work, when oats replaced half the corn and soybean meal in the diet, gilts and barrows had better average daily gains (ADG) and reached finishing weight (90 ± 5 kg) about 1 week earlier than controls fed a corn–soybean meal diet. Further studies using boars and barrows fed lysine-supplemented naked oat diets showed that the 50% substitution level again provided better ADG (0.93 versus 0.88 kg/day) and fewer days (139 versus 146) to finishing weight.

Swine behavior

Suckling piglets use their eyeteeth as weapons when fighting for a position at the sow's udder, but producers commonly clip the teeth at birth to prevent injuries. Previous work showed that piglets whose teeth were left intact had higher weight gains than litter mates with clipped teeth, at least in large litters, where competition is appreciable. A further experiment tested whether selective clipping can help compensate for the competitive disadvantage of piglets with a low birth weight. In 20 conventional litters of 12 piglets, all animals were clipped at birth, and the four piglets of lowest birth weight in each litter had lower daily gains and a higher death rate (17%) than their litter-mates. In 20 experimental litters, the four lightest piglets in each litter kept their teeth intact, whereas the heavier litter mates were clipped. Under these conditions piglets with a low birth weight had improved daily gains and reduced death losses (7%); however, some of their improvement appeared to occur at the expense of their heavier litter mates.

A detailed analysis of weight gains by suckling piglets showed that litters have particularly large differences in average weight gain during the first 3 days after farrowing. Some litters gained weight steadily during this period, while others gained little or lost weight for 1, 2, or 3 days after birth, presumably because of initial difficulties in the sow's lactation. Litters with poor initial weight gains had lower gains later in lactation, more variable gains, and tended to have higher death losses. A simple procedure for monitoring early gains might identify litters at risk and allow selective intervention to improve piglet production.

Carcass quality

Research on grading led to the October 1987 revision of the Canadian hog-grading standard, which was fully supported by the Canadian Meat Council and the Canadian Pork Council. Following this revision, the grading system is now providing the industry a more accurate estimate of the true value of a carcass.

ARC research, partly funded under the Ontario pork industry improvement program, has identified, under field conditions, environmental factors that can potentially influence the incidence of pale, soft, exudative (PSE) pork. Significant factors include the following: mixing unfamiliar pigs at the assembly yard, time of last feeding, duration of transport, and resting period at the abattoir.

POULTRY BREEDING

Poultry meat production

Synthetic strains of broiler parents have undergone selection for six generations to evaluate various multitrait selection programs. Selected traits in sire strains included the following: (*a*) body weight and crippling at 28 days in all programs; (*b*) feed efficiency for the period 28–42 days in program 1; (*c*) abdominal fatness of sibs at 47 days in program 2; and *b* plus *c* in program 3. In dam strains, the selected traits included body weight at 28 days, crippling, feed efficiency at 28–42 days, and hatching egg production of pullets to 40 weeks of age.

Analysis of five generations of selection in the sire strains revealed only small differences in response to the three programs. Selection for body weight and feed efficiency in program 1 appeared to improve these selected traits and reduce abdominal fatness as much as selection for the three traits simultaneously in program 3. Realized heritabilities were 0.4 or higher for body weight and up to 0.3 for feed efficiency; however, they were low at 0.15 for abdominal fatness. This low value was attributed to measurement only in sibs and to a poor response to selection after the first generation. It appeared that selection to reduce abdominal fatness will not be enough by itself to achieve the desired genetic reduction of abdominal fatness in broiler chickens.

Crossbred progeny tests of the sire and dam strains indicated that five generations of selection had improved the following: body weight at 28 days, by 60 g; body weight at 46 days, by 120 and 180 g in sire and dam strains, respectively; feed efficiency at 46 days, by 2–3%; and leanness at 47 and 48 days, by a reduction of about 20% in abdominal fatness in sire strains only.

Poultry egg production

The efficiency of egg production and hence profit from a flock of layers depends on several traits. The challenge for the breeder is to apply appropriate selection emphasis on each trait to maximize advances in efficiency or profit. A profit function was developed for inclusion in the best linear unbiased prediction procedure to allow breeding values for seven commercial traits to be used to generate income and expenses for each candidate for selection. This will permit individuals to be ranked on gross profit: income minus expenses with the objective of improving egg stocks in relation to the economics of the poultry industry.

A 4-year study of the effects on egg production traits of house, wing within house, and location within wing, i.e., battery and tier, showed no consistent effects across years or traits. No effects were significant for all traits, and there were few significant interactions. House and wing were significant more frequently than battery and tier. Although effects were not significant for any trait in all years, in some years, location effects and their interactions were significant for particular traits. For example, in one year, most location effects and their interactions were significant for age at first egg and mature body weight, but the opposite was true in other years. The frequency and pattern of significant effects varied greatly across years, with no apparent trend. It appeared that even in well-designed poultry facilities, effects resulting from location must be expected, and care must be taken in experimental design to ensure that treatment or genetic effects are not confounded with location.

Disease resistance genetics

During the past 4 years, efforts have been made to eradicate avian lymphoid leukosis (ALV) from ARC pedigreed chicken flocks. For four generations, White Leghorn hens, considered test-positive (reading > 0.4) for the group-specific antigen (gsa) of ALV using an enzyme linked immunosorbant assay (ELISA), were not used for breeding. The frequency of test-positive hens has been reduced from 10 to 4% for the 1983 and 1986 hatches, respectively. This reduction was much less than expected. Progeny of the 1986 hatch were tested within 10 days of hatch for gsa of ALV in feather pulp in order to explore the feasibility of removing chicks as early as possible to reduce the horizontal spread of ALV and perhaps find a more critical test. However, even though all dams had levels of ALV gsa in egg albumen of less than 0.4, 58% of their progeny had levels of ALV gsa in feather pulp of greater than 0.4 and 15% were greater than 2.0. Possibly, these high levels in feather pulp resulted from endogenous viral genes. Thus, in ARC Leghorn populations, levels in feather pulp did not sufficiently distinguish birds positive for ALV.

From 1983 to 1986, similar procedures were used to eliminate ALV from the broiler strains. A recent sampling of sera from 20% of chickens from the broiler sire strains indicated, by virus antibody test, that the flock was free of exogenous ALV.

Goose management and genetics

Successful artifical insemination of geese requires good methods of identifying ganders that produce high-quality semen. The relationship of redox (oxidation–reduction) potential or electron pressure of diluted ejaculates to concentration, yield, and motility of spermatozoa was examined in a Chinese and Synthetic (Chinese, Hungarian, and Pilgrim) strain. When only ejaculates with mature and immature spermatozoa, spermatids, and nonidentified forms were present, redox 1 was highly correlated with concentration ($r = 0.89$). Redox 2 (redox 1 adjusted for pH) was positively correlated with percentage of mature spermatozoa ($r = 0.81$) and negatively correlated ($r = -0.85$) with percentage of immature spermatozoa. Therefore, redox potential could be a biophysical index of concentration and maturity of spermatozoa in ejaculates.

To improve carcass leanness, heritabilities and phenotypic correlations of live body, carcasses, and dissected carcass parts were studied in ganders 18.5 and 19.5 weeks old, ganders of a Chinese and Synthetic strain. The high heritabilities for such traits as live-body weight (0.67), intestinal plus leaf fat percentage of carcass (0.46), and total lean percentage of carcass (0.81) suggested that these traits could be improved fairly rapidly by selection. However, low phenotypic correlations (< 0.50) between live traits and such carcass traits would make indirect assessment for selection very difficult.

Eggshell quality

A laying ration in which vitamin D_3 supplement was replaced by the hormonal form, 1,25-dihydroxyvitamin D_3 (1,25-D_3), significantly improved eggshell quality of older White Leghorn laying hens (from 59 to 80 weeks of age) based on measurements of specific gravity, percentage of shell, and deformation. The optimal level in the feed was 5 µg/kg; and at 7 µg/kg, signs of toxic effects, such as markedly decreased egg production, egg size, and feed consumption, were noted. Another metabolite, 24,25-dihydroxyvitamin D_3, added alone to feed at 5 µg/kg did not support eggshell calcification and when added with 1,25-D_3 at equal concentration (5 µg/kg each) tended to suppress the effect of 1,25-D_3 added alone. The results indicated potential for 1,25-D_3 as a feed supplement in improving eggshell quality of the last 100 eggs of the production cycle where the problem of shell quality is most severe.

The genetic parameters of six shell quality traits and percentage of intact eggs between oviposition and grading in two generations of

White Leghorn hens were studied to determine the best traits for use in programs to reduce egg breakage. Heritability estimates tended to be highest (0.29–0.59) for specific gravity, shell weight, percentage shell, and shell weight per unit surface area; somewhat lower (0.21–0.33) for compression fracture strength; and lowest (0.10–0.26) for nondestructive deformation. Estimated genetic correlations between percentage of intact eggs late in the laying year and eggshell quality traits early in the laying year were highest (0.50 and 0.62) for specific gravity and lowest (0.23 and 0.30) for shell weight, respectively. These latter correlations were considerably lower than preliminary estimates based on the first generation only and on a different statistical model. Considering heritability, genetic correlation, and ease of measurement, specific gravity would be the shell quality trait of choice for reducing losses from breakage.

POULTRY NUTRITION

Feedingstuff evaluation

Work on methodology for estimating bioavailable energy and amino acids is nearing conclusion. Suggested changes to the bioassay for true metabolizable energy were evaluated, including extension of the preliminary fast to 48 h, delivery of water to the crop, and provision of supplemental glucose. None of the changes improved analytical precision and, because they involve additional work, are not recommended.

Understanding of bioassay theory was advanced by detailed investigation of factors contributing to the precision of TME_n estimates. Practical application was found in improved experimental designs that distribute birds among treatments to maximize precision within the limits of available resources.

A calcium lignosulfonate pellet binder was found to contain TME_n at 4.90 ± 0.52 MJ per kilogram of DM. Steam pelleting did not alter the amount of TME_n of a grower diet with (40 mg/kg) or without the binder.

Nutrient requirements

Estimation of lysine requirements of broilers from hatch to 42 days of age is in progress. Protein accretion, fat deposition, body weight change, and the efficiency of nutrient utilization are the principal response criteria. Carcass composition data from preliminary experiments have allowed the identification of relationships among carcass components and the derivation of prediction equations. One outcome was the development of a protocol that may eliminate the need for the slaughter and analysis of control birds when experimental treatments are initiated.

Naked oats

Naked oats, *Avena nuda*, contain approximately 185 g of crude protein and 17 MJ TME_n per kilogram of DM. This feedstuff was evaluated for laying hen diets in which it was substituted for corn and soybean meal to provide iso-energetic, iso-lysine diets. Egg yield and egg production were not influenced by inclusion of oats up to 600 kg/t but were reduced at 795 kg/t. Egg weight and the ratio of grams of egg to grams of feed were higher for oat diets compared with corn–soy. Egg production of hens fed oats without protein supplementation was reduced by 9% compared with corn–soy; when supplemented with feed-grade methionine and lysine or with canola meal at 150 kg/t, production was similar to the control diet, whereas the ratio of grams of egg to grams of feed was greater. Color of yolk was markedly less intense, whereas shell weight was higher with oat diets. Minor effects of sourness and decreased intensity of egg flavor were associated with oat diets at taste panels conducted at the Food Research Centre. No other detrimental effects of oats on table eggs were noted.

Naked oats caused inhibition of growth and decreased feed efficiency when fed to starter broiler chicks at 1–3 weeks of age. These effects were increased by raising oat β-glucan levels and by inactivation of endogenous oat enzymes. This finding indicated roles both of glucan and of its breakdown by enzymes endogenous to the grain in the magnitude of the growth inhibition. Autoclaving resulted in partial improvement in the value of oats for chicks, but extended holding at postautoclaving temperature had no further effect on nutritive value. Steeping in water for 48 h caused a loss of soluble protein and hence of nutritive value. It was concluded that naked oats were a valuable dietary ingredient for poultry layers as well as for growing broilers, and as a locally produced feedstuff naked oats can be substituted for purchased or imported corn and soybean meal.

A protocol for reducing egg hatchability

Populations of ring-billed gulls have increased enormously during recent years in eastern Canada. They have become a nuisance or pest in some urban localities and are of concern to agricultural producers. Their ravenous consumption of earthworms during soil cultivation might affect soil aeration, and they possibly spread disease among domestic animals.

In response to an enquiry from the Canadian Wildlife Service of Environment Canada, chicken eggs were used as a model for developing a protocol to test the feasibility of using pharmaceutical mineral oil to impair the hatchability of ring-billed gull eggs. The chicken egg model permitted the application of various amounts of oil over the surface of eggs that contained embryos of known age. Results showed that the application of a thin oil film over the entire surface of the eggs at 17 days of incubation was the most effective and reduced hatchability to <4.5%. Embryo death occurred within 1 day of application.

Based on the data from the chicken egg model, a field trial was designed that confirmed that spraying a thin layer of mineral oil over the entire surface of ring-billed gull eggs late in their incubation period decreased hatchability to <3.5%. In addition, the time the brooding birds spent incubating eggs containing dead embryos was extended to beyond the end of their breeding season.

SHEEP PRODUCTION

A technical bulletin was published summarizing the results of sheep production research at ARC. New technology and management strategies that evolved or were developed from the research program are described. A comprehensive bibliography is included for those who wish to refer to original research publications, and a list of additional references is provided for readers who seek more detailed background information.

Studies using record of performance (ROP) data

The effects of systemic variations in prestation environment on the growth performance of Suffolk ram lambs on test at Canadian record of performance (ROP) test stations were evaluated from 1820 records. Age of dam, birth type of ram lamb, rearing type, and entry group had no effect on the average daily on-test weight gain. However, entry weights between 16 and 40 kg and prestation weight gains between 0.27 and 0.71 kg/day were required to maximize on-test weight gain.

Development of specialized synthetic sire and dam strains

Genetic and phenotypic parameters of reproductive traits such as fertility, litter size, multiple birth, and fecundity and their relationship with body weight and age at breeding were determined from 2380 lamb records representative of the ARC synthetic sire (strain 1) and dam (strains 2 and 3) strains. The lambs were bred at 6.5–7.5 months of age during January, May, or September by synchronization of the estrous cycle and exposure to rams at the synchronized and follow-up estrus. Heritability estimates for litter size and multiple birth were 0.22 and 0.13, respectively, for ewes that lambed, suggesting that slow genetic progress in these traits can be achieved by selection. However, heritability estimates for body weight and age at breeding were high, as were their genetic correlations with prolificacy and multiple births. These results suggest that selection of ewe lambs based on age and body weight at breeding is more beneficial for genetic improvement of litter size and multiple birth.

The inheritance of active and acquired immunity traits in ARC synthetic sheep strains was evaluated by quantifying the humoral immune response in ewes and lambs after inoculation of pregnant ewes with ovalbumin. Titres of antiovalbumin antibodies (a-Ova) were measured by enzyme-linked immunoabsorbent assay (ELISA) techniques. Strain did not affect ewe immune response, but sire-within-strain was highly significant. Titres in pregnant ewes 12 and 30 months old were higher than in pregnant ewes 21 months old. The number of lambs in utero did not significantly affect immune response of the ewe. Heritabilities of titre from a paternal half-sib analysis were 0.27 ± 0.17 for all ewes and 0.57 ± 0.25 for only the pregnant ewes. The effect of strain of lamb on lamb a-Ova titre approached significance, and sire within strain was highly significant. Lamb a-Ova concentration increased to 18 h after birth but declined thereafter. The size of the litter in which a lamb was born had a highly significant effect on the lamb's acquired immunity, with titre decreasing as litter size increased. The heritability estimate for lamb a-Ova concentration from a paternal half-sib analysis was 0.38 ± 0.11; and 0.28 ± 0.15 from the sire variance component of a full-sib analysis. When lamb titre was considered a maternal trait (lambs nested within their maternal grandsires within strains), the maternal grandsire variance component was negative. The average a-Ova concentration of lambs that died between sample collection and 120 days of age was less than that of lambs that survived ($P < 0.01$).

In a cooperative study with the Animal Pathology Division, the effects of subclinical Maedi-Visna infection on ewe productivity were evaluated. Data from ARC (60% of the total) made up one of five data sets from four flocks. Overall, subclinical infection with Maedi-Visna reduced lambing rates. For ewes that lambed, no effect on the litter size was noted. Birth weights of lambs born to infected ewes 3–4 years old were 3–6% lower than those of noninfected ewes. However, there was no effect on the birth weight of lambs born to infected ewes that were 1–2 years old or more than 5 years old.

Reproductive physiology

Follicular growth and ovulation. Prepubertal gilts treated with 750 international units (IU) of pregnant mares' serum gonadotropin and 72 h later with 500 IU of human chorionic gonadotropin (hCG) continue to be used as a source of preovulatory follicles to investigate the role of and interrelations between follicular granulosa (GC) and theca interna (TC) cells in the ovulatory process. The regulation of production of prostaglandin E_2 and prostaglandin $F_{2\alpha}$ by dispersed GC and TC isolated from preovulatory follicles at different stages of maturation has been examined because of the pronounced increase in production of these compounds associated with follicular rupture. Both GC and TC produced prostaglandins. After exposure of follicles to hCG in vitro, the capacity of both cell types to produce prostaglandins was increased. However, the magnitude of the increase was limited by the availability of arachidonic acid (AA), the principal precursor of prostaglandins. The results were also consistent with the concept that luteinizing hormone–hCG regulates follicular prostaglandin production by two different, but complementary, modes of action; an increase in AA availability through activation of lipolytic enzymes and an increase in prostaglandin synthetase, both of which are dependent on cell type and stage of differentiation.

Cryopreservation of ram semen. When freezing extended ram semen in 0.5-mL straws, the spermatozoa suspension is cooled to −11°C (supercooled) before spontaneous ice formation occurs. This ice formation was very deleterious when freezing mammalian embryos but could be overcome by "seeding" the medium with ice crystals to induce ice formation at higher temperatures. Supercooling did not affect the integrity and fertilizing capability of ram spermatozoa in semen frozen under optimum conditions, indicating that seeding was not required.

Manipulation of photoperiod. Biodegradable or silastic implants containing melatonin have been given at various times to rams exposed to alternating cycles of 8 and 16 h of light daily or to normal and reverse annual light cycles. Preliminary results have shown that rams given silastic implants at maximal testicular regression were able to achieve maximal scrotal size 6–8 weeks earlier than untreated rams. In contrast, biodegradable or silastic implants given at maximal testicular redevelopment were unable to influence the rate of testicular regression.

ANIMAL FEED SAFETY AND NUTRITION

Mycotoxins

The 1986 corn crop in eastern Canada was seriously damaged by *Fusarium* infection. When moldy grain was fed to swine, reduced feed intake, poor weight gains, and reproductive problems were reported. Studies have continued on mycotoxin contamination of animal feedstuffs focusing on detoxification of moldy feedstuffs, evaluation of toxic metabolites of *Fusarium*, metabolism and residue studies in animal food products, and feeding trials with pure mycotoxins.

Preliminary results indicated that roasting was an effective method of reducing deoxynivalenol (DON) and zearalenone concentrations in moldy corn. More research is necessary to determine the chemistry involved during roasting and to evaluate the toxicity of chemicals generated during the roasting process. The addition of bisulfite and heat treatment reduced available DON in moldy corn. A feeding trial compared the effects of two control diets, a DON-contaminated diet and the same DON diet with the moldy corn pretreated by autoclaving and with sodium bisulfite. Pigs offered the DON-contaminated corn (untreated) diet ate less feed and gained less weight than those on the other three diets. Treating the DON-contaminated corn with bisulfite made the resulting diet more acceptable. Similar responses were observed when the study was repeated with pure toxins. When a propionate-based feed preservative was added to clean and DON-contaminated diets, the propionate improved overall performance of pigs fed the control and DON-containing diets but did not reduce specifically the adverse effects of DON.

Optimization of the chick embryo bioassay for testing the toxicity potential of fungal metabolites has continued. The advantages of the assay are that it is not specific for certain mycotoxins and it gives a broader index of toxicity than methods for individual mycotoxins. Several laboratories are evaluating the assay for commercial use.

A major trial determined the effect of feeding pure DON at 0–19.1 mg/kg on growing gilts over a 14-day period. No overt signs of illness or emesis were observed. There was a linear decrease in body weight of 0.9 kg for each milligram of DON in each kilogram of diet fed over the period. In a 7-week study with barrows, feeding naturally contaminated wheat-based diets with DON at 3.9 and 5 mg/kg did not adversely affect swine performance. No major clinical or histopathological effects were observed.

When moldy feed is given to livestock and poultry, the safety of toxic residues in animal food products is of concern. Over a 12-day period, ^{14}C-DON was added to the feed of White Leghorn laying hens. Residue levels increased with each subsequent egg laid until the last exposure to the toxin. Residues quickly declined once the birds were switched to clean feed. Analysis of the eggs showed that only 10% of the radioactivity present could be identified as the parent toxin.

Pesticide residues

Fenvalerate (FEN). A study on the metabolism of (^{14}C-carbonyl) FEN in laying hens given a single dose of ^{14}C-FEN showed that approximately 85% of the administered ^{14}C was eliminated in excreta within 24 h. Eggs laid within 24 h contained radiocarbon mainly in albumen; in egg yolks residues peaked in 4–5 days. Radiocarbon residues were detected mainly in the liver and kidney; in other tissues and organs the residue concentrations ranged between nondetectable to parts per billion. Analysis of the ^{14}C-metabolites indicated that the pesticide was metabolized mainly by the cleavage of the ester bond followed by extensive hydroxylation of the acid moiety at the carbon-bearing carboxyl group, the methyl group, or both. The data showed that laying hens, when accidentally exposed to FEN residues in the diet at concentrations <50 mg/kg, should not have appreciable residues in eggs and meat.

m-Phenoxybenzaldehyde (m-PBald). The disposition of *m*-PBald, the primary metabolite of a large number of synthetic pyrethroids, was investigated in laying hens. Hens given a single dose of ^{14}C-*m*-PBald voided $>90\%$ in the excreta within 24 h. Very little residue was found in fat, liver, kidney, tissues, and eggs. Residues, if any, dissipated rapidly during the withdrawal period. A large number of ^{14}C-metabolites, including small amounts of *m*-PBald, were found in the excreta. Preliminary data indicated that *m*-PBald was metabolized by a number of complex pathways.

Fats and oils

Perinatal nutrition. Experiments on the fat accretion of fetal pig carcass and tissue have shown that the total fat content of the fetus is not greatly influenced by the gestation diet of the sow. The fat content of fetal internal organs appears to be carefully regulated, but changes do occur in the fatty acid content of fetal heart, liver, lung, and kidneys, especially as gestation proceeds. Changes in tissue fatty acid composition may influence metabolism, since enzyme activity is sensitive to the environment in which the enzyme is situated.

Feeding trials with neonatal pigs have begun using Jerusalam artichoke flour incorporated into a milk replacer formulation. The study is expected to determine whether the flour provides the piglet with protection against diarrhea. Initial calculations indicate that using this flour could greatly reduce the cost of sow milk replacer.

Canola oil. Studies continue to evaluate the nutritional and toxicological properties of canola oil for the United States Food and Drug Administration to gain unrestricted access to

American markets. After suckling the sow for 1 day, piglets were fed artificial milk replacer diets containing canola oil or high erucic acid rapeseed (HEAR) oil for 2, 4, 6, 9, 12, or 15 days, to determine if and when myocardial lipidosis occurred. Control piglets were kept with the sow for the same time periods. The results indicated a high incidence of myocardial lipidosis in 1-day-old piglets nursed by the sow; however, on continued suckling, myocardial lipidosis disappeared by day 5. Feeding canola oil resulted in a 13% incidence of myocardial lipidosis beyond the effect observed in suckling piglets. Feeding HEAR oil containing 40% erucic acid gave an 87% incidence of myocardial lipidosis.

Methods were developed to measure the digestibility of the diets in piglets fed the artificial milk replacers. Studies evaluated fatty acid utilization by piglets using perfused hearts. Preliminary results indicate that erucic acid is metabolized by young piglets.

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G.A. Mulligan, B.Sc.	Weeds, cabbage family (Cruciferae)
D.B.O. Savile, B.S.A., M.Sc., Ph.D., D.Sc., F.R.S.C.	Plant rusts
G.E. Shewell, B.Sc., M.Sc.	Lauxaniid flies (Lauxaniidae), blow flies (Calliphoridae)
D.M. Wood, B.A., M.A., Ph.D.	Parasitic flies (Tachinidae)

VISITING SCIENTISTS

J. Huber, B.Sc., M.Sc., Ph.D.	Chalcid wasps (Chalcidoidea)
W.I. Illman, B.A., M.Sc., Ph.D.	Economic fungi

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[1] Seconded from Libraries Division, Finance and Administration Branch.

[2] Seconded from Canadian Forestry Branch, Agriculture Canada.

INTRODUCTION

The Biosystematics Research Centre (BRC) is a unique centre of excellence for Biological Resources in Canada. BRC is responsible for conducting systematics research to discriminate and correctly identify insects, mites, spiders, plant parasitic nematodes, vascular plants, and fungi that occur in Canada. BRC also maintains primary reference collections of living or preserved organisms to document their identity, variability, and distribution; to draw upon unique genetic capabilities for industrial applications; and to assist biologists in the agri-food, forestry, environment, and health sectors in the evaluation of these organisms as potential crops, pests, biological control agents, and environmental quality indicators.

BRC provides Canada with a team of scientists and technicians with the expertise needed to maintain and update a comprehensive national biological information system on soil and water organisms, beneficial and pest insects, and economic plants and fungi. It serves as the main vehicle for the flow of biosystematic and biological control information nationally, and between Canada and other countries. The National Identification Service of BRC processes more than 100 000 organisms every year for clients in the agri-food (75%), forestry (15%), environment (9%), and health (1%) sectors. Requests for authoritative identification are received from across Canada from Agriculture Canada Research Branch, Canadian Forestry Service, and Food Production and Inspection establishments, provincial diagnostic laboratories, universities, and industry. The National Identification Service affects directly or indirectly the marketability of billions of dollars of agricultural and forestry products annually and provides the basic biological information in support of a sustainable agriculture in Canada.

Reprints of research publications and copies of this report are available from the Biosystematics Research Centre, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6; Tel. (613) 996-1665.

Robert Trottier
Director

NATIONAL IDENTIFICATION SERVICE

A total of 109 457 identifications were made during 1987 on insects, mites, spiders, nematodes, vascular plants, and fungi, involving 1869 shipments of material. Seventy-five percent of the identifications benefited the agri-food sector. The major clients of the service were Agriculture Canada, 33% (18% for Research Branch and Food Production and Inspection Branch, and 15% for Canadian Forestry Service), followed by Canadian universities, 18%.

During 1987, 101 442 specimens of insects, mites, spiders, and nematodes were identified, 30% for Agriculture Canada and 19% for Canadian universities. Departmental projects supported during 1987 by the National Identification Service included the following: economic insect survey (St. John's); alfalfa blotch leafminer (Charlottetown); vegetable and field crop insect research (Kentville); integrated control of strawberry and raspberry pests (Saint-Jean-sur-Richelieu); management of pome fruit pests (Vineland); leafhopper-transmitted diseases of cereals in the eastern Prairie Provinces (Winnipeg); biological control of weeds (Regina); and cutworm ecology (Lethbridge). Among the projects originating in the Canadian Forestry Service are the following: forest insect and disease survey (Fredericton, Sault Ste. Marie, and Victoria); pine wood nematode survey (Fredericton); biological control of gypsy moth (Sainte-Foy); field investigations of the spruce beetle (Edmonton); and cone and seed insect studies (Victoria). Plant Health Division of Food Protection and Inspection Branch submitted specimens for identification from the oriental fruit moth survey and whitefly survey, as well as import and export interceptions.

During 1987, 5489 collections of vascular plants were identified; the main users of the service were Canadian universities (32%), other federal departments (21%), and Agriculture Canada (14%). The identifications provided to the research stations were associated with some of the following projects:

horticultural production on peat and mineral soils (St. John's); pollen collected from berry crop insect investigations (Kentville); studies on alfalfa (Brandon); biological control of weeds (Regina); and weed control (Swift Current, Beaverlodge, and Edmonton). Canadian Forestry Service, Sault Ste. Marie, was assisted with identifications relating to a survey on the European birch leafminer, and Food Production and Inspection Branch divisions were provided with information and determinations in the preparation of a manual for inspectors, identification of noxious weeds and seeds related to import and export problems (Plant Health Division), and identifications of pollen (Laboratory Services Division). Ontario Hydro required assistance in the identification of pollen affecting line workers. A significant number of enquiries were also received from the Poison Control Centre for the identification of plants suspected of poisoning and from the Ontario Ministry of Agriculture and Food for the identification of crop weeds.

A total of 2526 collections and cultures of fungi were identified during 1987. Major users of the service were the general public (51%), followed by Agriculture Canada (26%). Assistance was provided to the research stations and forestry services in the following areas: identification of fungi relating to rutabaga root crown disease, decline of black spruce plantations, and deterioration of trees damaged by insects (St. John's); potato diseases (Charlottetown); needle cast of black spruce, forest insect and disease survey (Fredericton); alfalfa root diseases, biological control of the spruce budworm (Sainte-Foy); Colorado potato beetle control (Saint-Jean-sur-Richelieu); greenhouse vegetable pathology (Harrow); forest insect and disease survey (Sault Ste. Marie); crop drying in near ambient air temperature, diseases of stored products (Winnipeg); leafcutter bee chalkbrood, foliar mold project (Saskatoon); effect of soil fungi on phosphate solubilization; safflower red tip disease (Lethbridge); postharvest storage rot of fruit (Summerland); Douglas fir dieback and forest disease survey (Victoria). Food Production and Inspection Branch divisions were assisted with problems of fungi on imported ornamentals and on corn for export (Plant Health Division), and the identification of molds in haylage toxic to horses (Laboratory Services Division). Industrial consultants were supported in a study on fungal contaminants in greenhouses. Many enquiries were also received from the Poison Control Centre and from various provincial health laboratories and hospitals for the identification of mushrooms suspected of poisoning.

RESEARCH AND TECHNOLOGY TRANSFER

Soil and water organisms

The eight scientists in the soil and water organisms project conduct systematic research on the decomposers, parasites, and predators constituting the arthropod communities that characterize soil and aquatic habitats. The resulting information base permits analysis of the complex historical and ecological factors that determine the distribution of species and the composition of communities, and provides the basis for assessing and monitoring the quality of soil and water biotopes.

Among the activities completed during 1987 were the first synopsis of the water mites of peatlands and marshes in Canada summarizing the frequently overlooked role of these organisms as predators and parasites of insects, and a review of nearctic orthocladiine chironomids clarifying the nomenclature and identity of many taxa. Research on the North American species of the holarctic oribatid genus *Zachvatkinibates*, and analysis of an important symbiotic relationship between a gall midge and a fungus, were successfully completed. Substantial progress was made on systematic treatment of water mites associated with spring and ground water habitats, studies of the biting midge genus *Culicoides* and the chironomids of spring habitats, a handbook on the genera of oribatid mites, a guide to the mites of apple orchards, and a revision of the holarctic predaceous rove beetles genus *Philonthus*. Field work by staff members and donations by cooperating researchers added significant collections of water mites, oribatid mites, biting midges, and rove beetles to the National Collection during 1987. Study of the newly acquired specimens, especially from the western United States, British Columbia, and the Yukon, is contributing important new data to improve our understanding of the identities, distributions, and relationships of the species that occur in Canada.

Beneficial insects

Live insect parasites and predators were imported from 10 foreign countries by the Biocontrol Unit, and cultures of 28 beneficial species were distributed to 11 Canadian research establishments for laboratory testing or release against seven agricultural pests. The *Liberation Bulletin*, an annual record of the deliberate movement of native and imported beneficial insects within and into Canada, was brought up to date with the completion of volumes 47–51 (1983–1987). The publications will be distributed in 1988. A national newsletter, which will be published annually, was also established for biological control workers across Canada.

Major revisions were completed for the rove-beetle genus *Phlaeopterus*, predaceous beetles found only in western North America; for the mymarid (Chalcidoidea) genera *Schizophragma* and *Stethynium*, egg parasitoids of leafhoppers; and for the 50 Canadian species of the spider genus *Pardosa*, which are important predators in meadows and crops. Also clarified for the first time were the species identities of *Anaphes iole* Girault (Mymaridae), an egg parasitoid with potential for controlling *Lygus* bugs in a variety of crops using mass production and inundative releases, and *Alabagrus stigma* (Brullé) (= *A. stigmaterus* Cresson) (Braconidae), which has been used in a number of biological control programs against corn borers and rice borers. Two new species of the ichneumonid genus *Gelis*, which parasitize spider eggs, were also described.

Colleagues from seven institutions in the United States also cooperated with project members to operate 30 Malaise and intercept traps for seven months in selected sites of the Appalachian Mountains and the Eastern Seaboard. Analysis of the material that was collected will contribute toward a much more accurate knowledge of the distribution and species composition of beneficial insects in eastern North America.

Insect pests

New records and species of plant nematodes (Bolonolaimidae) were found in Canada; these are being incorporated into a major manual on nematodes of agricultural importance. In a study being conducted in cooperation with Simon Fraser University, evidence was found for morphological and genetic (DNA) differences among Canadian isolates of the pine wood nematode. Descriptions of two new species of nematodes parasitic on grape in British Columbia, with a review of the distribution of *Xiphinema* in western Canada, were submitted for publication.

A major work on the cutworm moths of the genus *Euxoa*, a group that includes a number of economically important species (red-backed cutworm, dark-sided cutworm, sandhill cutworm, among others), was published during the year. The revision is presented in a format aimed at both specialists and field biologists. Two revisions of groups of holarctic cutworm genera were published.

A faunal analysis of the leafhoppers of insular Newfoundland and the Cape Breton Highlands was published. This lists many new provincial records, including new species, newly introduced European species, and major range extensions of western North American species.

The first part of a catalog on bark beetles (Scolytidae and Platypodidae) of the world, based on 22 000 references, has now been published. A second part on the taxonomy of bark beetles is in progress. Short papers on distribution and biology of several species of bark beetles and weevils were published. The first volume of a manual to the weevils of Canada, a large family that will be treated in two volumes, is now under review.

Economic plants

For barley, *Hordeum*, studies of three species complexes were completed. A comparative study of 53 genera of crucifers closely related to the important crop group *Brassica* (including canola, mustard, and cabbage) was carried out, and another study of brown mustard, *B. juncea* (L.) Czern., was undertaken. For the alfalfa genus, *Medicago*, taxonomic papers were prepared for five of the species complexes. As well, taxonomic studies were completed of some species in economically important relatives of *Medicago*: sweetclover (*Melilotus*), fenugreek (*Trigonella*), and clover (*Trifolium*). The new phyletic technique of assessing relationships by analysis of chloroplast DNA was undertaken for *Brassica*, *Hordeum*, and *Medicago*, and studies were completed of some species in the last two genera. Preparation of an atlas of pollen grains of major Canadian honey plants was initiated. Giant foxtail, *Setaria faberi* Herrmann, a new weed of corn and soybeans in Ontario, was studied. Competitive studies of Proso millet, *Panicum miliacium* L., were completed. Studies were completed of the chromosomal races of cypress spurge, *Euphorbia cyparissias* L. Leafy spurge, *E. esula* L., a very variable complex, was found to be best treated as comprising one species only. Scentless chamomile, *Tripleurosperum perforatum* ined., was found to comprise several chromosome races. Several aquatic weeds, including *Elodea canadensis* Michx. and *Hydrocharis morsus-ranae* L., were the subject of additional papers. Several plants useful as wild forage were also studied. *Artemisia* species (wormwood and sage), were examined, particularly pasture sage, *A. frigida* Willd., a component of winter forage on the Prairie Provinces and in British Columbia. Sedge (*Carex*), which provides species important as forage in wet meadows, was the subject of a symposium that was organized and several articles that were prepared. Several forage grasses were also studied, including *Poa eminens* Presl, *P. labradorica* Steud., *Danthonia spicata* (L.) Beauv., and *D. intermedia* Vasey.

Economic fungi

In a revision of the mushroom genus *Xeromphalina* in Canada, *X. campanella* (Fr.) Kuhner & Maire was confirmed to be one of the commonest softwood decaying agarics in Canada and the United States, and two new species were described. A monograph of *Xerula* in Canada was completed; this genus of root-decaying agarics produces valuable antibiotics. Cultures of three species were sent to West Germany for antibiotic tests. In conjunction with the United States Department of Agriculture, a new cultivar of a leaf pathogen of corn, *Marasmiellus paspali* var. *americanus* Redhead & Latterell, is described from Central America. Some endomycorrhizal fungi of the genus *Glomus* kept their mycorrhizal capacities after a single-stage freeze-drying treatment designed to conserve mycorrhizal strains and provide scientists and industries in high-quality inoculum. A survey of the ericoid mycorrhizal capacity on blueberries of 17 species of *Oidiodendron* is complete; four were found to be aggressive in forming mycorrhizae. Molds associated with urea formaldehyde foam insulation were studied for adverse health effects in relation to the production of allergens, mycotoxins, and volatile organic compounds. A monograph was completed of the *Mycosphaerella* species occurring on Brassicaceae, which includes canola, many vegetables, and weeds. Species of *Phaeosphaeria* cause diseases of major cereals, forages, and wild grasses. A new monograph covers 118 species, 33 of which are new. It includes native species as well as those apt to be intercepted on imports. A report was published on the symptomatology and distribution of a disease of sainfoin, new to North America, caused by *Septoria orobina* Sacc. Descriptions and illustrations of four important rusts were completed for *Fungi Canadenses*. A biological control fungus that is very effective in Hawaii for the control of *Ageratina riparia*, a weed that was introduced from Mexico, was shown to be a state in the life cycle of a smut fungus, *Entyloma compositarum* Farlow. In conjunction with staff at the Plant Research Centre, two species were found to be involved in the phytophthora disease of alfalfa; *Phytophthora sojae* Kaufmann & Gerdemann is a destructive pathogen, whereas *P. megasperma* Drechsler is mildly pathogenic. It was determined that the phytophthora disease of soybean is caused by *P. sojae* and not *P. megasperma*, as generally assumed.

The National Mycological Herbarium grew by 1344 specimens to a total of 252 434. Also received during the year, but still awaiting integration into the herbarium, are 4500 specimens of plant parasitic fungi donated by the Research Station in Saskatoon and some 3000 specimens of Manitoba fungi collected by Dr. Guy Bisby and Professor A.H.R. Buller, donated by the University of Manitoba.

The Canadian Collection of Fungus Cultures handled 726 requests, sending out 528 cultures in response: Canada 67%, United States 21%, other 12%.

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J.D. Hobbs,[2] B.Sc. Transferred to Department of National Defence, May 1987	Systems and programming
M. Levesque, B.Sc., M.Sc. Resigned 21 August 1987	Crop drying
H. Pitt, B.A. Transferred to Research Program Service, 13 October 1987	Administration
C. Pon, B.Tech., M.Eng. Resigned 3 April 1987	Computer systems
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[2] Seconded from Systems and Consulting Directorate.

INTRODUCTION

The following is a summary of the activities of the Engineering and Statistical Research Centre in 1987 and a list of the information published.

Phasing out of energy research is now complete and a series of reviews and summaries of work accomplished under 300 contracts with the private sector valued at $35 million was the focus for the year. Published reviews provide an overview of energy in agriculture in the Canadian context and form the basis for future decisions. Ongoing energy work is now integrated with other programs of the centre. The main effort is directed at the study of the tractor and implement interactions and their impact on soil conservation.

Patents continue to accrue as a result of food engineering research and the resulting commercial activity expanded. A major contribution was made to the development of standards for processing foods in flexible pouches.

Progress was achieved in developing objective techniques for the inspection of foods to establish the means for automatic inspection and grading. These techniques are being used by industry and regulators. Several instruments were developed to improve the efficiency and effectiveness of experimental work at several stations. Notable was the contribution of the new open path CO_2 analyzer to international research on atmospheric studies.

Further contributions to the economy of constructing farm buildings resulted from the structures research program. Work increasingly focuses on animal welfare concerns and improved environmental control. Results indicate that two-tiered pig pens are beneficial. Technology transfer was accomplished effectively on a national basis through the plans and publications of the Canada Plan Service.

A major contribution to the production of pickling cucumbers was achieved with the development of a harvester, which increased the return to the grower. Data for future decisions on transplanting systems were published.

The statistical program provided wide-ranging support to projects and programs across Canada. New methodology was developed, and overall major impacts on the efficiency and effectiveness of experimental work and research were achieved. Increasingly, commercial software is being used for data analysis, reducing the need for expanding the in-house library of software.

The engineering data base was kept up-to-date and information on agricultural engineering research was disseminated nationally. The program for maintaining scientific equipment at Ottawa establishments was transferred with the staff to Plant Research Centre, after 10 years of operation.

To meet the demand for constraints on resources, the engineering programs of the centre were reviewed and focused on soil conservation; animal welfare; food; and the application of advanced technology to the agri-food system.

The following report provides only highlights of the specific achievements during 1987. Additional information on these and other items can be obtained upon request from the Engineering and Statistical Research Centre, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6; Tel. (613) 995-9671.

Peter W. Voisey
Director

ENERGY

All contracted-out work from the energy research and development in agriculture and food (ERDAF) program has been completed and the results of the liquid fuels, biomass combustion, and energy crops research have been reviewed and assessments published. The technology for fermentation of several agricultural residues and interim alcohol conversion efficiencies has been established. The biological conversion of agricultural cellulose to a fermentable sugar, although possible, will require a technological breakthrough to be economically viable. It was found that fuel alcohol production can only be economic at a large industrial scale; farm-scale production is not profitable.

Canola oil cannot be used directly as a replacement for diesel fuel and an oil substitution level acceptable to engine manufacturers would be too low to be worth pursuing.

The work on the energy crops showed that the biomass yields are not significantly different from conventional crops. Optimum agronomic practices still need to be developed to achieve viable energy crop yields integrated with other croppings. The identification and development of kochia as an alternative forage crop for the rejuvenation of saline land was a major spinoff from the energy crop program. The work on Jerusalem artichoke as an energy crop has resulted in the identification of potential new markets for special sugars processed from this crop.

Surveys of available agricultural biomass suitable for energy production did not find any underutilized resource. However, it was found that better use could be made of chaff. Considerable work has now been initiated in the private sector to develop collection systems for using chaff as cattle feed.

FOOD PROCESS ENGINEERING

Patents were granted in seven European countries on the Agriculture Canada–Atlantic Bridge Company blancher system. This system continues to make inroads in the commercial market with several sales this year, including two installations in Canada.

Canadian Patents and Development Limited (CPDL) filed for patents on the Engineering and Statistical Research Centre (ESRC)–Food Research Centre (FRC) extrusion–microwave process. This process has considerable commercial potential with interest being expressed by processors.

The Canadian Government Standards Board (CGSB) *Use of flexible laminated pouches for thermally processed foods* was prepared and published for use in the Canadian industry.

Workshops were conducted on food texture and on thermal processing. Food texture training sessions were given to representatives of industry and educational institutions. A review of time–temperature indicators for frozen foods was presented at the annual meeting of the Canadian Frozen Food Association.

A graduate student from the University of Manitoba, who did his thesis research at ESRC, successfully completed his Master of Science degree program.

INSTRUMENTATION AND AUTOMATION SECTION

Several machine vision projects for grading and inspecting agricultural products were completed. A tomato grader, developed under contract, has been placed on a grading line at a canning plant in southern Ontario. A tobacco grader was demonstrated at the Delhi Research Station. The "veal inspector," transferred to industry previously, is now in commercial production and in use by industry.

ESRC, in cooperation with Land Resource Research Centre (LRRC), National Research Council (NRC), and McGill University, participated in the NASA first international field experiment (FIFE) program in Manhattan, Kans., to measure CO_2 and water–vapor flux densities for assessing biomass growth and evapotranspiration over large areas. The analzyer used to measure these fluxes was developed by ESRC.

An electronic eggshell thickness gauge and computer interface for eggshell strength instrumentation was developed and installed at the Animal Research Centre.

A 176-chamber thermogradient seed germinator for weed research studies was developed and installed at the Regina Research Sation. An IBM-AT personal computer controls the individual temperature regime in each chamber.

Instruments and equipment were developed for grinding soil samples to crush air-dried soil samples to a maximum of 2-mm size for micronutrient studies, including metals such as iron, zinc, and manganese; a revolving fertilizer-digesting oven was developed for Plant Health Division of Food Production and Inspection Branch; and surgery rooms were designed for small and large animals.

Assistance was provided to support departmental initiatives in grading and inspection programs, including wheat carrier ship inspection by machine vision, electronic identification (EID) of livestock, and instrumentation for crop environment assessment.

STRUCTURES AND MECHANIZATION

Structures

The Canada Plan Service (CPS) completed 10 plan sets each in metric and imperial units, and published 10 leaflets and six plans in French and 30 leaflets in English. To clarify legal liability, new structural plans contain notes to show where the local engineer should make structural design choices to ensure that the plan suits the particular farm site and local construction codes. In collaboration with the Canadian Society of Agricultural Engineering (CSAE), a technical session of invited papers on animal and poultry building ventilation was conducted. The resulting papers formed the base information for a new series of leaflets on the topic.

Based on research results showing how to change truss joint design because of the loss from the market of a plywood size commonly used for connections, the CPS re-engineered 31 trusses in two truss families (gambrel and single-slope).

A new procedure was developed to improve the reliability and efficiency of nailed connections in farm buildings.

Six two-tiered pens were installed at Ridgetown College of Agricultural Technology (RCAT) to conduct a cooperative full-scale test of a new pen design concept researched in collaboration with the Animal Research Centre. The pen design provides 1.7 times more floor space in a given size barn. Animal weight gains in the new system have been as good or better than control groups in single-level pens.

Collaborative work with Alfred College of Agriculture and Food Technology (ACAFT) showed that a wind direction sensor integrated with the indoor and outdoor thermostats in a naturally ventilated swine barn improved the environmental conditions inside the barn during cold weather.

Mechanization

Major design changes to reduce crop loss were made on a production cucumber harvester, in collaboration with Bick's Pickles, and field tested. The modifications increased the return by $250/ha for machine-harvested cucumbers. Two harvester manufacturers and some growers are adopting the improvements.

An applicator was developed to dispense fertilizer in various narrow-band patterns along the tree drip line in orchards. It enabled the Smithfield Experimental Farm to establish the optimum fertilizer distribution pattern. The desired pattern can be attained with existing fertilizer spreaders by slightly modifying them.

Collection of engineering data during semiautomatic mechanical transplanting of processing tomatoes in southwestern Ontario showed improved performance of tray plants, compared to bare-root transplants, including an increase of 2.3 times in worker productivity using cup-type transplanters that require only one worker per row, instead of two, to feed the mechanism.

The Agricultural Engineering Research and Development contract to revise seven sections of the *Canadian agricultural materials handling manual* was completed. Editing and printing are proceeding.

STATISTICAL RESEARCH

Support was provided to all commodity groups by designing experiments, analyzing data, maintaining and enhancing computer software, and conducting research on statistical methodology.

Collaborative work continued in animal science research. Studies showed that supplementing silage with fish meal increased the growth rate of calves raised in the Northern Clay Belt of Ontario. It was demonstrated that commercial eggshell breakage is reflected by laboratory measures of eggshell quality; thus the laboratory measures form a suitable and efficient criterion for breeding selection studies designed to reduce eggshell breakage. Studies on the growth of neonatal piglets suggested that the provision of supplementary water may promote survival, particularly when the sow is not producing sufficient milk, and that maintaining the teeth on the smaller piglets in a litter may decrease early mortality and increase the growth rate of these piglets. Other subjects studied were the nutritive value of naked oats for swine; the effects of dietary electrolyte balance in swine; the effects of swine farrowing crate design on piglet survival; the mineral content of stored dairy cattle manure; and the effects on swine growth of low dietary levels of several mycotoxins.

Investigations continued into methodologies for improving the accuracy, precision, and efficiency of the true metabolizable energy bioassays for poultry feedstuffs; the studies indicated that the protocol used at the Animal Research Centre is at least as accurate and precise as those used in other laboratories throughout the world. Formulas were developed for allocating resources so as to maximize the efficiency of the commonly used multi-diet apparent or true metabolizable energy bioassays; these results are also applicable to apparent digestible studies done, using larger animals. Development of a true metabolizable mineral assay continued; several design criteria that enhance the efficiency of such studies were identified.

Support for sensory food evaluation studies was provided by designing taste panel experiments and analyzing the resulting data. Subjects investigated included the effects of naked oats on the quality of eggs and pork, the effects of dietary fish meal supplementation on beef quality, the effects of accelerated aging on the quality of cheddar cheese, and the effect of different breeds and sex on the quality of pork. Research into methodologies to improve the accuracy and precision of taste panel experiments indicated that several commonly advocated response adjustment protocols for magnitude estimation data are unnecessary; a simple transformation leads to a robust and efficient analysis of such data.

The breeding programs for soybeans, alfalfa, potatoes, barley, and wheat were supported. The potential of brown spot (*Septoria glycines*) to reduce yields of several varieties of soybeans was demonstrated. Bacterial blight (*Pseudomonas syringae* pv. *glycinea*) did not adversely affect soybean yield. The vitamin C content of several commonly grown potato cultivars was found to vary throughout Canada.

Research for a new analytical technique for assessing regional trial data continued. A new statistical methodology that does not require the same standard (check) varieties to be grown at each location was developed. The method allows greater flexibility for a breeder to choose locally adapted cultivars as checks, and thus makes the trials more sensitive in identifying cultivars with specific adaptability. The computing system used to analyze the eastern cereal variety trials was modified to handle generalized lattice field layouts; based on historical data, this enhancement will, on average, improve the precision of such trials by 10%.

An efficient protocol was developed for estimating pest abundance and decision making in integrated pest management studies. The methodology obviates the necessity for counting all individuals in each sampling unit, but requires merely the separation of units into "heavily infested" and "not heavily infested" categories. Research was initiated into the estimation and interpretation of least squares means obtained from historical long-term data bases. When the data are grossly unbalanced, the standard algorithms often produce biologically unacceptable estimates. An examination of data concerning reproductive and vegetative material in weeds indicated that several conjectured relationships are not universally applicable to all species.

Statisticians advised researchers from more than 35 establishments throughout Canada on various subjects including experimental design, use of computer software, and data interpretation. This facility was used more than 160 times and represents an annual increase of approximately 20%. The computer systems and programming unit responded to more than 80 requests originating throughout the branch. A quarterly newsletter was distributed to all branch establishments.

The library of computer software continues to be used approximately 1000 times per month. Additions to the library included programs on quantal bioassay; Hayman's diallel cross, including the half diallel cross protocol; and an interactive program to determine the probability levels of several commonly used hypothesis test statistics. The on-line library of examples for programs and for the SAS and GENSTAT software systems was expanded. A monthly bulletin describing features and enhancements to these systems is distributed to personnel at more than 25 branch establishments.

Thirty requests for training in the use of general computer and statistical software from establishments throughout the department were satisfied. Developed software was distributed to four research–government establishments external to the department.

SUPPORT SERVICES

The data base on engineering research was kept up-to-date, particularly with North American results. Surveys were conducted on Canadian graduate theses in agricultural engineering and agricultural engineering computer programs. The results were published in two catalogs.

SHOP SERVICES

The program for maintenance of scientific equipment on the Central Experimental Farm was transferred to Plant Research Centre, releasing the centre from this responsibility after 10 years of operation. The machine shop continued its support of the engineering programs by constructing the research prototype equipment.

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INTRODUCTION

In support of the Research Branch mission to improve the long-term marketability of Canadian agricultural products, the Food Research Centre (FRC) provides assistance to Canada's food and beverage industry to become more efficient, productive, and competitive. The research programs cover the broad areas of dairy products processing, cereals and oilseeds processing, meat and poultry products, food composition and structure, sensory evaluation of foods, and nutrition and safety.

The primary clients of the centre are Canada's food and beverage processing industry and associations, other branches of Agriculture Canada, and other government departments and agencies. In addition to research services, the centre provides advisory services and expertise in the evaluation of research proposals for agencies such as National Sciences and Engineering Research Council (NSERC), National Research Council (NRC), and Canadian International Development Agency (CIDA). The staff members of the centre represent the branch, the department, and the country as a whole at national and international meetings.

The centre's staff make a significant contribution to the expert committees of the Canada Committee on Food. In addition, scientists participate in the international food programs of Codex Alimentarius, the International Dairy Federation, the Food and Agriculture Organization (FAO), the International Atomic Energy Agency (IAEA), and the International Consultative Group on Food Irradiation.

More emphasis is being placed on technology transfer to industry and government clients, promotion of collaborative long-term and short-term research projects, and improved mechanisms to ensure participation by the private sector in FRC research activities.

This report provides highlights of research activities in 1987. Publications and more information can be obtained by writing to the Food Research Centre, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6; Tel. (613) 995-3722.

N.W. Tape
Director

PROCESSING TECHNOLOGY

Extrusion cooking

Extrusion cooking is a well-known process technology used in the continuous production of a wide range of foodstuffs including snack foods, flat or crisp breads, modified starches, breakfast cereals, and pet foods. Research has been conducted for several years at the Food Research Centre, Ottawa, into mechanisms of the extrusion cooking process. Recently, it has been discovered that moisture-tempered starchy materials can be extruded under conditions which do not result in product expansion at the die face. This pliable unexpanded plastic mass rapidly hardens into a vitreous glass-like material. Upon subsequent exposure to microwave energy, the glass-like starchy material expands 3–5 times as much in volume, resulting in particulates of low bulk density. A patent application has been filed with the Canadian Patent Office. This process may have potential in the production of calorie-reduced snack foods and may also offer savings in process energy when compared to more conventional approaches. Further information may be obtained from Canadian Patents and Development Ltd., Ottawa.

Oat hulls

Oat hulls were assessed in laboratory and pilot plant experiments as potential press aids for the fruit juice industry. In order to deal with seasonal variation in fruit firmness, juice processors frequently have a requirement to add sterilized wood fibers or rice hulls to apple pulp. This practice ensures press operating efficiency and acceptable raw juice yields. These press aids are imported into Canada.

Laboratory tests, using apple pulp supplemented with 0.5–3.0% w/w press aids, showed average yields of raw juice of 78.0, 76.6, and 74.5% w/w for wood fibers, rice hulls, and whole oat hulls, respectively, relative to a control (no press aid) of 73.0% w/w. When oat hulls were processed into a slivered form, the average raw juice yield increased from 74.5 to 76.5% w/w. Pilot plant tests conducted in cooperation with the Smithfield Experimental Farm, using late season Ida Red apples with 2.0% w/w addition of slivered oat hulls, gave yields of 77.9% w/w compared to a control of 71.7% w/w. Both apple pulps had been treated with a pectinase enzyme prior to pressing, a common industrial practice. No quality defects were detected in the finished juice by a trained sensory panel. The 20 000–25 000 t of oat hulls produced annually in Canada are more than sufficient to meet the needs of the Canadian fruit juice processing industry. Replacement of imported press aids with oat hulls presents an opportunity for improving oat hull utilization in Canada.

Oat β-glucans

A variety of methods for the analysis of (1→3)(1→4)-β-D-glucan have been compared for their efficiency and reproducibility. A method based on Calcofluor precipitation gave somewhat lower values than methods employing a specific β-D-glucanase. A method based on a commercial kit (BIOCON) gave the most reproducible results, and has been used to monitor the β-D-glucan content of oat bran preparation in collaboration with POS pilot plant in Saskatoon. The Calcofluor method is best suited for assays of soluble β-D-glucan and has been used to follow the release of β-D-glucan from rolled oats subjected to various cooking methods.

Oat bran containing 15% β-D-glucan and less than 1% hull contamination, and oat gum (75–80% β-D-glucan) were prepared at POS for use in physiological studies. Rats adapted to a diet containing oat gum had reduced post-prandial insulin requirement and showed reduced serum cholesterol levels. Both effects were dose dependent. In clinical trials, oat gum reduced the peak increment above baseline of blood glucose and insulin in glucose tolerance tests in healthy subjects.

The effect of shear stress on molecular size and viscosity of oat β-D-glucan was further examined. At low shear stress normal pseudoplastic behavior was observed over an increasing and decreasing shear cycle, but higher stress for longer periods resulted in permanent viscosity loss and lower molecular weight as shown by high performance size exclusion chromatography.

The (1→3)(1→4)-β-D-glucanase content of commercial supplies of β-amylase was estimated by gel diffusion assay, by viscosity assay, and by using an insoluble complex of β-D-glucan with congo red. The three methods were generally in agreement but showed differences in ranking, especially when tested with some commercial cellulases.

Oat phenolics

Fractionation of methanolic extracts of oat groats and hulls by anion-exchange chromatography revealed the presence of a series of anionic, substituted cinnamic acid conjugates, trivially named avenanthramides. Two-dimensional thin-layer chromatography (TLC) showed groat extracts to contain more than 25 distinct avenanthramides, whereas hull extracts contained about 20. Some 15 were common to both groat and hull. The substances were purified by repeated column chromatography on Sephadex LH-20, using TLC to monitor purity, and crystallized from aqueous acetone. The complete structures of 10 avenanthramides have been elucidated, using ^{1}H- and ^{13}C-nuclear magnetic resonance (NMR), mass spectroscopy (MS), ultraviolet (UV), and hydrolytic techniques and confirmed by total synthesis.

These avenanthramides (i.e., substituted cinnamoyl derivatives of anthranilic acid) are structurally related to *N*-(3',4'-dimethoxycinnamoyl)-anthranilic acid, a potent new type of antihistamine and noninflammatory pharmaceutical recently synthesized and released in Japan under the name Tranilast. The presence of such compounds in oat grain represents the first reported occurrence in nature. A high-performance liquid chromatography (HPLC) technique has been devised for the quantitative analysis of oat avenanthramides. Retention time is related to substitution pattern, which enables predictive evaluation of complex mixtures of differently substituted avenanthramides.

A new group of phenolic acids has been found in aqueous alcoholic extracts of oat groats and hulls. These acids occur as conjugates, covalently linked to the amine function of several different *ortho* amine-substituted benzoic acids. One of these has been purified, characterized, and identified as 5-(4'-hydroxyphenyl)-penta-2,4-dienoic acid for which the trivial name avenalumic acid is proposed. The biological and functional activity of the avenalumic acids remains unknown; however, they are the ethylenic homologues of the well-known *p*-coumaric, ferulic, and caffeic acids, which are widely distributed in cereal grains and believed to be associated with antioxidant properties.

Oat proteins

The thermal denaturation of oat globulin was studied by spectroscopy and differential scanning calorimetry (DSC). There was a progressive blue shift in the fluorescence spectra and a red shift in the ultraviolet absorption spectra when oat globulin was heated at 100 or 110°C, indicating protein unfolding. DSC data showed a progressive decrease in enthalpy, indicating partial denaturation, a marked increase in denaturation temperature, and a decrease in width at half-peak height, suggesting aggregation of oat protein to form a more compact structure with high thermal stability and cooperativity. Heat treatment also caused a pronounced increase in activation energy and pre-exponential factor. Analysis of the soluble and insoluble fractions of heated oat globulin showed a redistribution of native and extensively denatured protein in the soluble and insoluble fractions, respectively.

The rheological properties of oat protein gels and oat protein–egg white co-gels were assessed by small amplitude oscillatory tests. Plots of modullii (G', G") versus frequency show that substitution of 25% and 50% of egg-white solids (EWS) with deamidated oat protein isolate (DOPI) did not result in a significant decrease in G' and G" over a wide range of frequency (0.01–10 Hz). Thus, EWS–DOPI co-gels have mechanical properties similar to those of egg white gels. The positive synergistic effect of deamidated oat protein and egg white in forming mechanically stable, thermally setting gels, offers a potential for oat protein utilization. However, this potential would be dependent upon a clear indication of the economic feasibility for the wet fractionation of the oat kernel.

DAIRY TECHNOLOGY

Psychrotrophic enzymes

Initiation of proteinase and lipase secretion by *Pseudomonas fluorescens* was stimulated by the addition of the iron siderophore, pyoverdine, produced during the late-logarithmic phase of growth. Excess iron in the growth medium repressed the synthesis of pyoverdine, lipase, and proteinase, and lipase was more sensitive to the repressive effects of iron than proteinase. A mutant deficient in pyoverdine production secreted significantly less lipase than did the parent strain, whereas production of the proteinase was unaffected. These studies strongly suggest that iron is the most important nutrient affecting extracellular enzyme production by psychrotrophs.

Spontaneous oxidation in milk

The incidence of spontaneous oxidation in Ontario's milk supply was examined by sensory evaluation of randomly selected samples. Approximately one-third of the 400 raw milk samples tested had this flavor defect, which ranged from slight to pronounced. The problem has been identified in other provinces, but it is particularly severe in New Brunswick. A previous retail survey revealed that as much as 40% of the fluid milk supply was oxidized. Although the causes of spontaneous and light-induced oxidation are not related, it is now apparent that both types of oxidation are involved in flavor defects of fluid milk sold at the retail level.

Cheese yields

Predictive formulas for yield of cheese from composition of milk can be used for reporting actual yields as a percentage of theoretically possible yields. This is important for helping cheese-makers assess their efficiency in attaining maximum yields. Three types of theoretical yield formulas were developed. They were derived from the general hypothesis that cheese is made up of three phases: a fat phase, a phase of a complex of paracasein and calcium phosphate, and a water-soluble phase, which consists of water, salt, and whey solids. These yield formulas were compared to various formulas obtained from the literature. It would appear that economically significant improvements in yield could be obtained by comparing actual yields with theoretical yields, although more work is needed on testing the theoretical formulas under commercial conditions.

Yoghurt over-acidification

Over-acidification has been a major problem in commercial manufacture of yoghurt. Six brands of plain commercial yoghurts were purchased from local retail markets and stored at 4, 7, and 10°C. They were analyzed weekly for 4 weeks for changes in acidity (pH), and total viable *Lactobacillus* and *Streptococcus*. The six brands varied considerably in their acidity, as well as in their starter populations. One out of six brands showed pH values higher than 4.0 and remained higher during storage, whereas four brands had pH values lower than 3.90, and the last brand examined had a pH close to 3.99 but only when stored at 4 and 7°C. In some brands there was a tendency for the pH to drop at 10°C. It is apparent that strains of both *Streptococcus* and *Lactobacillus* vary in their survival and in their ability to maintain a higher pH in yoghurt during storage.

Off-flavors in sterilized milk

Astringent and bitter off-flavors were observed in commercial samples of ultra-high temperature (UHT) milk heated by direct-stream injection. Some samples (< 1 month old) showed the off-flavor and had higher nonprotein nitrogen (NPN) than others. The other samples of UHT milk also developed off-flavors during further storage (up to 4 months). The off-flavor components from these milk samples were isolated by the chloroform–methanol extraction procedure of Harwalkar and Elliott. The extracted off-flavor components were further analyzed by fast protein liquid chromatography (FPLC), using Mono-Q anion exchange columns (Pharmacial) and polyacrylamide gel electrophoresis (PAGE). The FPLC and PAGE patterns of the extracts from astringent and nonastringent flavor correlated with one of the fractions resolved by FPLC. This fraction was heterogeneous by PAGE. The astringent and bitter off-flavors in UHT-sterilized milk were breakdown products of casein, as evidenced by reduction in β-casein in the stored UHT milk.

STRUCTURE AND SENSORY EVALUATION

Effect of processing on microstructure

Several processed foods were examined for microstructure by scanning electron microscopy.

Structural changes were observed in natural and processed cheeses used as ingredients in pizza during baking in conventional and microwave ovens. Changes related to the fat content of the cheese and its initial structure. Fat globules aggregated into large particles. Fat globule membranes and curd granule junctions vanished during baking. The structure of process cheese was affected less than that of stretched mozzarella cheese; the most severe changes were found in the microstructure of stirred-curd cheese that had been baked.

In skim milk cheese, casein particles were compacted and formed a continuous matrix. Advanced proteolysis affected the cheese microflora, which was particularly abundant on the cheese surface covered with a golden yellow slime.

In unripened goat milk cheese, the casein particles retained their individual entities. The microstructure of this cheese resembled that of cottage cheese made from cows' milk but the dimensions of the casein particles were more varied.

A core-and-lining ultrastructure was observed to develop in casein particles in paneer, a curd obtained by coagulating hot milk with citric acid and washing it with water. Frying the paneer in oil resulted in a compact protein structure. Subsequent cooking in salt water, however, restored the initial microstructure.

Rolled oats rich in starch and oat bran rich in β-glucan were investigated for microscopic structural changes and availability of selected nutrients after processing, after cooking and during in vitro and in vivo digestion. Oat starch was readily available for digestion by human salivary enzymes. Processing and cooking increased the rate of digestion, enhanced the release of β-glucans from the cell walls of starchy endosperm, and enhanced the rate of digestive breakdown in the rat small intestine of the subaleurone layer of oat endosperm. Phytin globoid of the aleurone layer and epicarp tissue was less affected by processing and cooking. The availability of Phytin as a source of dietary minerals phosphorus, potassium, and magnesium was dependent upon the endogenous and microbial enzymes present in the digestive system of the rat.

Sensory

The sensory unit collaborated with scientists from FRC, Ottawa Civic Hospital, Animal Research Centre (ARC), Brandon Research Station, Smithfield Experimental Farm, and External Affairs in a variety of projects on different commodities including cheddar cheese, oat gum, oat bran, apple juice, eggs, geese, pork, applesauce, and breaded mozzarella sticks. Assistance was provided to two major companies in the dairy industry in investigations on cheddar cheese aging and development of cheddar flavor. All these projects involved characterization of sensory properties through the use of trained sensory panels.

A palatable oat gum pudding-like product was developed and an oat bran bakery product formulated for clinical trials at the Ottawa Civic Hospital on the effect of β-glucans in diabetic and normal individuals.

Lactobacillus cultures were found to accelerate the process of aging cheddar cheese as determined by sensory panelists using reference standards for old and medium cheddar cheese.

Methods for producing oxidized and salty flavor defects found in butter were developed and standardized. Homogenized milk exposed to fluorescent light at 200 lx at 5°C for various amounts of time produced an oxidized flavor at specific perceived intensities. The necessary levels of NaCl added to homogenized milk to produce specific levels of perceived saltiness were also determined. The laboratory-produced off-flavors were accepted as flavor defect standards to be utilized by Agriculture Canada's dairy graders.

The firmness of four commercially available 2% butter fat creamed cottage cheese samples were evaluated by sensory and instrumental analyses. There was a perceptible difference in firmness among the samples, and results suggest that the mid-range in firmness of cottage cheese was liked best.

Vegetable fiber

The 80% ethanol-insoluble residues from parsnip, rutabaga, and squash were analyzed for moisture, nitrogen, starch, klason lignin, ash, and uronic orhydride. The starch-free residues after enzymatic hydrolysis were recovered and analyzed for neutral sugars, following acid hydrolyses and derivatization, as alditol acetates, by gas–liquid chromatography (GLC). The sum of lignin, cellulose, and noncellulosic polysaccharides showed the dietary fiber contents of celery, parsnip, rutabaga, and squash to be 1.29, 5.52, 2.52, and 2.80%, respectively, on a fresh plant basis.

The effects of feeding residues from celery, parsnip, and rutabaga at a 6% level to Sprague Dawlay rats were compared with diets containing comparable levels of oat and wheat bran fibers and a fiber-free diet (0.8% fiber). Parsnip fiber induced the highest moisture content and wheat fiber induced the lowest fecal fat concentration. Parsnip fiber induced a lower serum cholesterol to high density lipoproteins ratio than rutabaga fiber, and rutabaga fiber appeared to be the most extensively fermented by intestinal bacteria. Although the fasting blood glucose level was decreased with the parsnip diet, blood glucose response to a meal plus glucose was not different from that of the control. The three vegetable fibers appeared to be well tolerated by the animals, but the heart weight was decreased with parsnip and the liver weight was decreased with rutabaga; the spleen showed reduced weight with both parsnip and rutabaga. All fibers increased total fat excretion but showed decreased fat concentration (grams of fat per millilitre of feces).

FOOD SAFETY AND NUTRITION

Nutritional value of potatoes

The vitamin C and moisture contents of fresh raw table potatoes, commercially prepared frozen french fries, and french fries prepared for fast-food outlets were determined on samples available to the consumer from April 1986 to July 1987. The iron, zinc, copper, potassium, magnesium, and calcium content of all french fries, and the fat content only of the french fries prepared for fast-food outlets were also determined. In fresh raw potatoes there was a significant decrease in the mean vitamin C content of old potatoes from 21.77 mg/100 g in October 1986 to 9.57 mg/100 g in June 1987. However, new potatoes available in June and July 1987 had the highest vitamin C content, 31.2 and 33.8 mg/100 g, respectively. Moisture was fairly constant, ranging from 81.5% to 77.9%, with new potatoes having higher moisture levels. There were no significant differences in vitamin C, moisture, or mineral content in frozen french fries (unprepared) over time. However, there was a significant overall difference between large and small cuts of frozen french fries in vitamin C levels, 15.97 and 8.52 mg/100 g, respectively, and in moisture, 71.1% and 64.5%, respectively. The overall mean vitamin C content of french fries prepared for fast-food outlets was 10.76 mg/100 g, and it was significantly higher in September 1986, 17.89 mg/100 g, than in the following

December to June period. French fries from fast-food outlets using fresh potatoes had significantly higher levels of moisture, zinc, potassium, and calcium than those from fast-food outlets using parfried potatoes.

Fermented sausage

Bacteria from the genera *Pediococcus* and *Lactobacillus* and from the family Micrococcaceae are used in various combinations in Canada as starter culture organisms for controlled fermentation of dry sausages. The media currently in use for monitoring their performance during meat fermentations are incapable of easily distinguishing between pediococca and lactobacilli, and this issue is complicated further when commercial starter preparations contain only these two groups of bacteria. Using a modified medium keyed to distinguish between these groups on the basis of arginine hydrolysis, and adoption of the hydrophobic grid membrane filter (HGMF) technique, a successful procedure for differential enumeration of these two groups of organisms was developed. The counting technique and new medium should prove invaluable for following the progress of meat fermentations and has application for other types of fermented foods (dairy) and feeds (silage).

Commercial meat starter cultures used in Canada for the manufacture of Italian dry sausage were examined and found to be unsuited for these fermentations if traditional low temperatures (≤20°C) were used during fermentation. Controlled brief exposure to higher temperature (≤30°C) yielded acceptable results. A parallel study of streptococci in dry sausages revealed that enterococci grew during sausage maturation and this was most notable in samples ripened at higher temperatures. Of 312 streptococci isolated, 55% were enterococci (Lancefield's group D). These organisms could not be used as an accurate indicator of poor manufacturing processes for these products.

D-amino acids

The reverse phase (RP)-HPLC method for determination of D-amino acids in dietary proteins was further extended and refined. A method for the determination of D-amino acids in cheese was elaborated. By using this method it was proven that the nutritional quality of milk proteins in cheese baked on the surface of pizza remains unchanged during baking in conventional as well as in microwave ovens.

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INTRODUCTION

The Land Resource Research Centre (LRRC) conducts national programs in land resources research, including agrometeorology and soil surveys. Land use studies, and disciplines such as chemistry, physics, pedology, agroclimatology, mineralogy, and other biological and environmental sciences are brought to bear on problems of sustaining the quantity and quality of the natural resource base for a competitive agricultural industry.

During the year work was begun on the methods for monitoring the trends in key soil quality characteristics, as a basis for future programs to counter land degradation in Canada. Significant progress was made on the most appropriate methods and models to predict soil erosion under Canadian conditions. Other research clarified the importance of noncrystalline inorganic components in influencing the behavior of soils.

LRRC developed a new concept in resource mapping called "Agroecological Resource Areas" for the purpose of integrating soil–climate–yield and management data. In addition, a radically improved computerized simulation model for wheat was completed and validated. A much improved understanding was gained of the potential for certain bacterial strains to degrade herbicides in the soil and the significance of bound pesticide residues in organic soils.

Considerable advances were made in specific measurements of changes in the soil under conservation production systems. Organic matter research shed light on new organic binding agents in mineral soils and further developed composting techniques using peat, liquid manures, fish wastes, and rock phosphate.

Advances in soil–crop–weather models are making these models extremely powerful predictive tools for assessing the impact of the extreme conditions on crop production. Assessments of the impact of climatic change have been made, and user-friendly software and a user manual were developed for estimating soil moisture content for irrigation scheduling. There has been significant progress on characterizing the risks of freezing for crop production in Ontario, and leading edge work has been continued on the instant assessment of crop growth rates by measuring CO_2 and vapor flux from low-flying aircraft.

In soil survey work, initial steps were taken to shift soil surveys toward more cost-effective products, more soil quality monitoring, and somewhat less emphasis on local detailed surveys. Maps at the broad scale of 1:1 million covered 73 million hectares and those at moderate to fine detail covered 1.7 million hectares. Maps showing the suitability of soils for specific uses were prepared, covering such subjects as deep plowing and cropping requirements in specific areas. In this regard specialized systems development was a top priority. Major components of the Canadian Soil Information System (CanSIS) have been replaced by ARC–INFO software, making machine-readable information available to other agencies, and greatly increasing the power of the information base.

Further information on the accomplishments of LRRC in 1987 are provided in this report. Additional information can be obtained from the Land Resource Research Centre, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6; Tel. (613) 995-5011.

J.L. Nowland
Acting Director

RESEARCH SECTION

Soil quality criteria and assessment

Selected criteria and properties that are important attributes of good-quality agricultural soil have been identified. These are soil flexibility, which is the ability of soil to support alternative profitable crops, and soil sustainability, which is the ability of soil to sustain repeated high yield. Soil flexibility and sustainability are controlled by soil climate and soil properties, such as soil temperature, water supply, structure, organic matter content, reaction, and salinity. A national program to monitor the trends toward degradation of agricultural soil quality is being developed.

Loss of soil quality by erosion

Progress has been made in searching the published and unpublished literature for the most appropriate existing methods and models to predict soil erosion under Canadian conditions, especially those which occur during freeze–thaw cycles and in the spring. Measurements of soil erosion under several cropping practices have continued in the Peace River region. The erodibility by wind of soils representing a range of textures has been measured in Saskatchewan. In southern Ontario, the effect of tillage and crop residue management on water erosion has been measured, using a portable rainfall simulator. Severely eroded and non-eroded soils in eastern Ontario have been sampled to determine chemical and physical changes that result from long-term erosion. Maps of wind and water erosion risk in the Prairie Provinces have been prepared for printing. A preliminary manual has been prepared for a global assessment of soil erosion and other forms of degradation. Progress has been made in identifying the chemistry of the cements involved in stabilizing the "quick clays" of the Champlain Sea sediments.

Eight soil conservation demonstrations have been initiated at the Central Experimental Farm. Displays and information packages have been prepared for Soil Conservation Week and for Agriculture Canada exhibitions. Newsletters and inventories of soil conservation activities, personnel, and resource materials have been prepared for Soil Conservation Canada.

Mineralogy and soil quality

The work on the mineralogy and K availability of five southern Ontario soils and five British Columbia soils, where the K deficiency problem exists, is being continued. The results obtained so far have indicated strong interactions between the various forms of K (soluble, exchangeable, and fixed) and clay mineral compositions. This information is useful for assessing and predicting K fertility status as well as for recommending K fertilizer application rates.

A working example of how to characterize noncrystalline inorganic components in soils was presented by studying three pedons from Quebec and Ontario containing a considerable amount of free Fe, Al, and Si. By applying selective chemical dissolution methods, approximate amounts of various Fe, Al, and Si compounds were estimated. The identification of these compounds was successfully performed by evaluating differential X-ray diffraction data before and after chemical extraction. The study showed a trend that noncrystalline Si compounds were concentrated in surface horizons, whereas noncrystalline Fe and Al compounds were concentrated in lower horizons.

The collection of the available mineralogical information on Canadian soils (approximately 500 pedons) was completed, criteria for clay mineralogical classes were defined, the mineralogical data of approximately 350 soil samples selected from the collection were classified, and the information is being summarized into map form for the preliminary mineralogical map of Canada. In this form the information will be more easily related to the important soil characteristics such as texture, K-supply, swelling, shrinking, and water-holding capacity. New mineralogical information was added by describing an interstratified chlorite–smectite mineral from carbonate rocks and soils and a ferrian saponite from basic rocks.

Completed processing of physical, chemical, and mineralogical characterization of selected southern Ontario soils and fractions therefrom as well as corn and alfalfa crops grown thereon. Information was obtained on levels of agronomically important minor elements such as Cu, Zn, Sr, and Mn in surface and subsurface soils and crops in order to assess spatial variability and relationship between element levels in soil, mineral fractions, and crops.

The Mineral Analyses Service provided 2186 X-ray diffractograms, including 100 X-ray powder diffraction photographs and 337 infrared absorption spectra, to contribute supportive data to at least 20 research papers and reports on mineral characterization of Canadian soils, mineral weathering, soil acidification, acid sulfate soils, clay–organic complexes, and methodology development for mineral identification and quantification. The recent replacement of a computer component for a fully automated X-ray diffractometer by a new one with a large capacity has increased a storage capacity for data nearly three times and has facilitated data processing. Continued progress in all research activities as planned should lead to significant advances in the interpretation on the relationships of mineral compositions to the important soil characteristics.

Prairie regional land evaluation

A new concept of resource mapping called "Agroecological Resource Areas" (ARA) was developed for purposes of integrating all the soil, climate, yield, and management data in the prairie region. Maps of Alberta, Saskatchewan, and Manitoba (1:2 M) have been completed, and Manitoba has been digitized on the ARC-INFO system. In addition, a comprehensive integrated data base for crop production, tailored for application in modeling, was developed for Manitoba.

A computerized crop simulation model for wheat was completed and validated against empirical data. Results indicated that the model predicted annual yields within 10% of measured values in all zones of Manitoba. Using the data compiled in the data base, long-term wheat yields in the form of probability density functions were calculated for all soils in each ARA in the agricultural area of the province. The Manitoba Crop Insurance Corporation, Prairie Farm Rehabilitation Administration (PFRA), Ducks Unlimited, and the provincial soil-testing laboratory are interested in the ARA Maps and the yield probability functions for use in molding the output for their application.

The Food and Agriculture Organization crop growth model was modified to predict crop growth periods and cutting cycles for forage crops. Data from field trials were assembled to validate the model, and these indicated that estimates of potential forage yields were acceptable, but more calibration was necessary to predict yields under moisture stress. Progress was made in developing a structure for the oilseeds model, but testing was hampered by lack of yield data.

Statistics Canada data for 1981 and 1986 were used to characterize the cropping systems in Manitoba. Two computer programs were developed to sort and type each census farm. Preliminary results in Manitoba and Alberta indicate that the ARA maps are well suited for differentiating the major cropping systems in the prairie area.

Discussions with Ducks Unlimited (Winnipeg) defined common agriculture–waterfowl objectives for soil conservation in upland agricultural areas. A joint research proposal to use remote sensing for monitoring cropping systems in the prairies has been prepared. The use of remote sensing to identify areas of uniform productivity is being evaluated.

Interactions between inorganic and organic soil components

The reactions of Al with phyllosilicates are of great interest to agriculture. A new polynuclear hydroxy–Al–montmorillonite complex with an exceptionally large basal spacing was prepared. The polynuclear hydroxy–Al were preferentially adsorbed over monomer Al; the maximum amount adsorbed was only 400 meq/100 g of montmorillonite. The complex was thermally stable to 700°C. More than 75% of the interlayer space was vacant. Organic molecules of glycerol entered into the spongy structure. The spongy surfaces of the complex showed catalytic activity.

The iron and fulvic acid (FA) formed complexes of different strengths and stabilities. Some of the Fe was "loosely bound" and was adsorbed on the surfaces of FA as hydrous ferric oxide. FA reacted with polynuclear hydroxy–Al cations. The FA–polynuclear Al–OH complex was stable and was adsorbed by montmorillonite. The 001 XRD reflection was measured at 19. Repeated water extraction of FA–montmorillonite revealed an exponential relationship between the accumulated extracted FA and number of extractions. Drying of the FA–montmorillonite complex at 40°C lowered the extractability of FA.

A low temperature O plasma procedure has been developed with optimum oxidation time. This method permits the removal of soil organic matter without distorting the integrity of soil samples; thus it is possible to observe the association of organic matter with inorganic soil particles. Microscopic observations of treated samples showed the replacement of aggregates by discrete grains. The water table level in a profile determines the nature of the organometallic complexes that accumulate in the B horizons. A study of Quebec Podzolic soils showed that Bf, Bhf, and Bh horizons developed in profiles whose mineral soil surfaces were >35 cm, between 35 and 0 cm, and <0 cm, respectively, with respect to the reference level that was taken as the water table position in the spring.

Amorphous soil materials are very reactive components. The interactions of atrazine with Fe and Al oxides were studied, and the high-performance liquid chromatography (HPLC) and microfiltration methods identified the equilibrium constants for the sorption of atrazine and hydroxyatrazine and the apparent rate constants as important parameters.

Pesticides in Canadian soils and their uptake by plants

Three species of *Pseudomonas* capable of utilizing the herbicide atrazine (2-chloro-4-(ethylamino)-6-(isopropylamino)-*s*-atrazine)as a sole source of carbon were isolated from a soil with a long history of atrazine application. It was shown that microbial dechlorination of the herbicide atrazine may occur in soil after the removal of one of the alkyl groups. Examination of *Pseudomonas* species for their plasmid content by gel electrophoresis revealed no detectable plasmids. It was suggested that the atrazine degradative ability in these strains is encoded by the genes on the bacterial chromosomes.

Arthrobactor sp. strain TEI isolated from a cornfield soil (Brandon, Man.) exposed to the herbicide EPTC (*s*-ethyl-*N*,*N*-dipropylthiocarbamate) degraded this herbicide effectively and could grow on EPTC as the sole carbon source. The degradative capability of the isolate was associated with one of the indigenous plasmids harbored by this bacterium. It was shown that the degradation of the herbicide was mediated by a 50.5-MDa plasmid in the cell. The loss of this plasmid resulted irreversibly in mutants unable to degrade EPTC. The transfer of this plasmid from TEI to EPTC degradation-deficient (*E*-) mutants restored completely their capability to degrade the herbicide, showing a correlation between EPTC-degrading ability and the presence of this plasmid. The EPTC-degradation proficient bacterial strain also degraded other herbicides such as butylate and vernolate. Results obtained provided an insight into the probable mode by which dietholate, an extender, prolonged the efficacy of thiocarbamate herbicides applied to soils.

In an organic soil exposed to deltamethrin ((*s*)-α-cyano-3-phenoxybenzyl *cis*-(1*R*,3*R*)-2,2-dimethyl-3-(2,2-dibromovinyl)2,2-dimethylcyclopropane-carboxylate) for more than 3 years the bound residues amounted to 16% of the initially added insecticide. The bound residues were characterized as the parent compound and its acid metabolites. The microbial population including bacteria, actinomycetes, and fungi decreased considerably from the initial numbers. A bacterial species capable of utilizing deltamethrin as a sole source of carbon was isolated from the soil.

Studies concerned with the airborne residues of triallate and trifluralin in Saskatchewan indicated that vapor transport is a major route for the dissipation of these herbicides from the treated area. Increased carry-over of both these herbicides can be expected in dry years.

Soil organic matter properties that influence herbicides persistence and movement were measured, and sorption and degradation effects were investigated. Five chemical species were monitored for atrazine. During the experimental period, free and sorbed atrazine and hydroxyatrazine were observed to be formed in addition to the material that became bound with the soil component.

It was established for the first time that endomycorrhizae can have a significant effect on the atrazine relations of corn and they can influence not only uptake but also allocation and metabolism of atrazine within corn plants.

A novel pressure extraction technique for the extraction of pesticides from plant tissue was developed. The technique eliminates the need for expensive and time-consuming chemical extraction procedures and allows determination of pesticide compartmentalization within plant tissue.

In clay loam soil fields cropped to corn at the Animal Research Centre, three herbicides – metolachlor, cyanazine, and atrazine – were applied and their residues monitored in soil and drainage water. The concentration of the three herbicides in soil decreased with time. The presence of metolachlor, cyanazine, and atrazine was also detected in effluents from tiles. It appears that transport of the herbicides occurred in water via soil macropores.

Soil conserving production systems

Two experimental locations, one at the Central Experimental Farm (CEF) in Ottawa and the other at Barrhaven in Nepean, on which the soil-conserving practices are to be evaluated were established. Spraying, tilling, and harvesting equipment was modified to confine wheel traffic so that compaction goals of the project could be addressed. The 1987 season was excellent for crop production; crop yields averaged 9500 kg/ha at CEF and 10 640 kg/ha at Barrhaven. Differences in soil type also dramatically affected corn grain moisture at harvest, as indicated by 12% higher moisture at Barrhaven. The growing season was relatively dry and wheel traffic associated with planting and spraying significantly and positively affected yields at Barrhaven but not at CEF. As this was the initial year for the study, no information was obtained on tillage effects. Ridging of corn at the six-leaf stage and soybeans at R-1 did not adversely affect final yields.

A crop-monitoring program was tested. Emergence rates of corn were monitored. Dry matter accumulation was measured at the 6–8 leaf stage, at tasseling, and at dent. Significant spatial variability among blocks was apparent at the CEF site, but treatment comparisons within blocks should still be possible. Root samples were taken within and between rows at the 6–8 leaf stage and at tasseling to estimate the relative root distributions with depth.

Soil temperature probes were constructed and installed. The probes were monitored successfully throughout the growing season. A tillage–crop–weather–soil interaction simulation was successfully implemented on our computer. For regular weekly monitoring of soil water content on 29 plots a system of in situ soil probes was developed. Parallel pairs of stainless steel rods remained in the soil in corn or soybean rows for measurement by time-domaine reflectometry (TDR) over four depths to 60 cm. The TDR instrument (IRAMS) was used to measure and store the data each week, after which the data were dumped to computer for storage and analysis.

Methods were developed for extraction of selected fauna, including Collembola (springtails) and Acari (mites) from undisturbed samples (7.5 cm diam. × 5 cm). Micromorphological samples were taken on both sites for preparation of thin sections and soil blocks to assess structure and soil pore pattern.

Cyanazine and metolachlor concentrations were monitored in selected plots at the CEF location. Based on data obtained over a 25-day period from application, the half-life periods ($t_{0.5}$) for the parent chemicals were 11.8 and 6.2 days for metolachlor and cyanazine, respectively. Using all the data, the respective half-life periods increased to 48.1 and 34.7 days, respectively.

Soil physical quality in relation to water and solute movement

The Guelph permeameter, which measures the soil's ability to absorb and transmit water, has been used to measure the variability of a field site before initiation of water and chemical transport experiments. Analysis of these data and the application of mathematical models to the flow from an augered hole have resulted in improved procedures for use of the Guelph permeameter.

The shrinkage and swelling of soil during drying and wetting results in cracks and fissures of major consequence to water and chemical transport in soil. In 1987, the field experiments measuring shrink–swell behavior on a clay soil showed the maximum shrinkage yet recorded during the experiment. The recovery swelling had not taken place until late fall. Soil samples were taken for more detailed analysis of the pore space geometry on a microscale.

Soil water quality beneath earthen storage tanks for manure has been analyzed. Initial results indicate that more than pore water velocity data will be required to interpret nitrate translocation patterns.

A study is under way to investigate the influence of additions of straw and wood chips on soil–water properties of the surface soil.

Soil organic matter and composts

Silt and clay fractions separated from four soils were found to be higher in total C, total N, amino acid–N, amino sugar–N, and ammonia–N but lower in unknown–N than the coarser soil particle size fractions; thus most of the soil–C and soil–N was found to concentrate in the smaller particle size fractions.

A new organic binding agent for holding together soil particles to form aggregates was identified. This was the result of chemical, infrared, ^{13}C nuclear magnetic resonance (NMR), and mass spectrometric analyses of soil aggregates separated from six different soils. It showed that long-chain aliphatics consisting of monoesters and polyesters of alcohols and fatty acids were prominent components which could be involved in binding soil particles. Subsequent tests in the laboratory confirmed that long-chain aliphatics were indeed organic binding agents in soil aggregation.

Assistance was given to two commercial companies with the preparation of peat-based composts from finfish and shellfish wastes. Composts of peat and liquid manures as well as floating peat on liquid manure lagoons were found to be suitable procedures for producing inexpensive nitrogen fertilizers and for curtailing pollution. Igneous rock phosphate was solubilized during composting to plant-available forms.

Climate assessment and information

Current estimates of soil moisture conditions and forecasted yields of wheat, barley, and canola were prepared and disseminated for the prairie region at regular intervals during the growing season in 1987, using moisture-budgeting procedures and improved crop yield models. These assessments are important to the agricultural industry for management decisions such as whether to crop or summer-fallow and for developing marketing strategies.

User-friendly software and a user manual were developed for estimating soil moisture content and scheduling irrigation at the farm level with a microcomputer, using the budgeting approach. Agricultural researchers and specialists in Quebec and the Atlantic Provinces have expressed much interest in this software and have received it for evaluation and use. This software was also used in cooperative work with UNICEF and with Ethiopia. Field tests on strawberries and potatoes verified the versatile soil moisture budget as an efficient method to schedule irrigation for optimum growth and yield.

Improved models were developed and are being used to compute risks of extreme soil temperatures during winter months in the Atlantic region for winter survival zonation. Sampling and analyses procedures for characterizing soil climates were evaluated and the results provide useful guidelines for on-going efforts to improve climatic classification by including effects such as texture, drainage, and vegetative cover. Soil environmental data were gathered for developing predictive models of corn emergence and of freeze–thaw penetration as it affects winter damage to plants and soil erodibility. Significant progress was made in characterizing freeze risks in Ontario on a geographic basis and data were gathered for predicting fall frost, using heat balance calculations. Climatic resources for apple production in Quebec were evaluated, using a zonation approach, and calibration of an apple yield model was begun in collaboration with Saint-Jean-sur-Richelieu Research Station.

Research support was provided to the Atlantic Advisory Committee on Agrometeorology in climatological assessments of hay-drying indices and heat units available for corn production. A summary of the impacts of climate variability and change on soil moisture problems in the Atlantic region was prepared and presented to researchers and extension specialists at a soil moisture workshop.

Training programs for three Brazilian scientists were developed and carried out in agroclimatology.

Crop production

A 3-year field study comparing corn varieties with different development rates and growth strategies was completed. Comparison of leaf architecture and maintenance costs as estimated from dark respiration rates of these varieties is under way. Field data collected on root depth and density of corn, soybeans, and barley through the growing season were analyzed. Dry matter data for corn, soybeans, and barley collected over a 3-year period were edited and summarized in data files.

A leaf area model was extended to calculate leaf area development and senescence on an individual leaf basis, resulting in a more accurate method of prediction. This will prove useful in future growth models designed to evaluate the contribution to yield from individual leaves.

The development of an open-path CO_2 and H_2O analyzer was completed and it was successfully used to measure the hourly rates of net photosynthesis and transpiration for a corn crop for most of the 1987 growing season.

Because of recent progress in monitoring crop growth and water use using airborne-mounted sensors, Agriculture Canada in conjunction with National Research Council, several federal departments, and McGill University were funded by NASA and invited to participate in the First International Satellite Land Surface Climatology Project field experiment in Kansas. The regional exchange of CO_2 and water vapor was successfully mapped by flying grid patterns at constant-pressure altitude over an area 15 km × 15 km during three very distinct periods in 1987. This provided the first measurements on a scale directly compatible to satellite measurements. This type of data will provide the agricultural industry an excellent opportunity for improving techniques of remote-sensing surface variables such as surface temperature, albedo, vegetation, and soil moisture conditions from the four major types of environmental satellites (NOAA, GOES, LANDSAT, and SPOT). It should also have very useful implications in developing techniques for quantifying various environmental impacts on crops.

SOIL INVENTORY SECTION

Mapping

Soil landscapes 1:1 million scale. This is a long-term project to compile a map of the soil landscapes of the whole country at a scale of 1:1 million. The maps are being digitized into CanSIS, and each area on the map (polygon) is described by a standard set of attributes stored in computer files. New mapping was completed in southern British Columbia (45 million hectares), Newfoundland–Labrador (21 million hectares), and southern Yukon (7 million hectares). Unpublished information has already been used for future land use analysis in the prairies. Further requests have been received from Ontario Hydro for soil conditions along transmission lines and from Canadian Forestry Service for soil data to match the national forestry inventory.

Detailed regional and local surveys. These surveys are conducted at the request of and in cooperation with provincial Ministries of Agriculture, Natural Resources, and Environment. They research complex environmental relationships to guide agricultural land management and planning, but their results are also applied to urban fringe planning, forestry, and wildlife management. Mapping scales vary from 1:100 000 to 1:20 000 (survey intensity levels 4,3, and 2).

This year field mapping has been completed in the areas of Musgravetown–Lethbridge, Nfld. (2000 ha); Woodstock–Florenceville, N.B. (8400 ha); Rouville County, Que. (13 000 ha); Elgin County, Ont. (88 000 ha); Duck Mountain, Man. (130 000 ha); rural municipalities of Rhineland, North Norfolk, and Victoria, Man. (88 600 ha); Melfort, Wood Mountain, and Cypress Hills, Sask. (1.2 million hectares); Pincher Creek, Alta. (20 000 ha); and St. Paul, Alta. (84 000 ha); and Whitehorse, Y.T. (55 000 ha).

In addition, scientists in the Soil Inventory Section have supervised contract surveys usually done under the Economic Regional Development Agreement (ERDA) or the Agricultural Food Development Agreement (AFDA) in Nova Scotia, New Brunswick, Saskatchewan, Quebec, and the Yukon. The titles of maps published from these surveys are listed under Publications.

International soil resources map, 1:1 million scale. The structure and contents of a digital data base for a 1:1 million map of the world was prepared as the Canadian contribution to this project, which is being organized by the International Soil Reference and Information Centre, Wageningen, the Netherlands. A procedures manual to be used for a number of pilot projects was also prepared. One pilot project, covering part of southern Saskatchewan, compiled information according to this international data base.

Interpretations

Interpretation studies and systems. The section conducts studies that promote the scientific assessment of soil and land for various forms of land use. Some of these studies are linked to a particular survey, whereas others are independent and help develop assessment systems that ensure consistent results across the country.

All published soil surveys contain interpretations for agricultural land uses. In addition, individual studies include suitability of organic soils for vegetable crops in Newfoundland, forest site evaluation in northern Ontario, an assessment of deep plowing for the amelioration of Solonetzic soils in Saskatchewan, and agricultural capability ratings based on revised climatic information in the Peace River District of British Columbia. Three interpretive systems were also produced. One of these, *Land capability classification for arable agriculture in Alberta*, was published. The other two, for agronomic interpretations of organic soils and selected forestry interpretations, were compiled for review.

Correlation

Regional correlation. The results of field mapping and manuscripts of results to be published as soil reports are reviewed to ensure they meet national standards. Reviews of 13 field projects were completed in the Prairie Provinces, Quebec, Atlantic Provinces, and the Yukon. Six manuscripts of soil reports were also reviewed.

Correlation studies. Applied research studies are conducted to establish the procedures followed by correlation. A study of the accuracy of detailed surveys in British Columbia, Nova Scotia, and Quebec has shown that mapped soils are sometimes described too narrowly. Traditionally, soil maps have claimed 85% accuracy. With soils precisely defined, maps can appear to be inaccurate when checked after fieldwork. Revised measures and tests for accuracy are recommended. Further correlation studies include standardized soil description fact sheets (Ontario), a study on the numerical classification of soils (Quebec), and a map of the pedoclimatic zones of Newfoundland.

Paleosol research. Studies in cooperation with the Geological Survey of Canada have shown that the morphology, chemistry, and mineralogy of soils in the unglaciated portion of the Yukon are clearly related to the age of land surfaces. A tour of some of these sites was arranged for the XII INQUA Congress held in Ottawa, August 1987, where two papers were also presented on this topic.

Monitoring

Soil temperature. Soil temperature within and below the root zone has been measured at regular intervals in various regions across the country, notably Manitoba, the Maritime Provinces, and the North. These results are now being incorporated into a revised classification of soil climate. Studies in the North, especially along the Norman Wells pipeline in cooperation with the Department of Indian and Northern Affairs, have shown that any disturbance can significantly raise the soil temperature, leading to changes in the depth of active layers above permafrost. This can lead to erosion.

Soil degradation. The Soil Inventory Section has been cooperating in a number of projects dealing with soil degradation. Maps showing the risk of erosion by water and wind and the degree and extent of soil salinity have been prepared for the Prairie Provinces. In addition, water erosion is being measured on field plots in the Peace River District of British Columbia and in southern Ontario, where studies are linked to the soil and water quality enhancement program. The Soil Inventory Section is engaged in preliminary studies to help plan a more comprehensive monitoring program.

Canadian Soil Information System (CanSIS)

Implementation of ARC–INFO software. The input and editing components of CanSIS have been completely replaced by ARC–INFO software. Soil maps are being converted to the ARC portion. One hundred and nineteen maps have been converted so far out of 800. The balance is to be converted by March 1989. Using this commercial software, data are now transferable to other agencies, and so far information in machine-readable form has been transferred to four clients. The characteristics of mapped soils are to be recorded in files in the INFO portion of the software. These files did not exist in the old CanSIS system, and have had to be created. A national working group has developed a standard data set to describe each soil, and the compilation of these files has begun. They, also, are scheduled for completion in March 1989. Files from the old CanSIS system that form no part of the new one have been moved into standard storage format. They include the Detail II profile descriptions and the Wetlands file. They remain available for consultation and additions, but will not be developed further.

Cartography

Printed maps and graphics. The Information Systems and Cartography Unit completed 29 soil map projects and three soil atlases for Agriculture Canada and 17 maps for Environment Canada. Two mapping projects were completed for Food Production and Inspection Branch. One showed the areas in Canada vulnerable to groundwater contamination by pesticides. The other was a map showing those areas in New Brunswick and Prince Edward Island that are free from bacterial ring rot. Eight special projects were completed, including a large soil conservation display. A total of 375 miscellaneous projects such as figures and diagrams for papers, conference poster displays, and other visual aids were also completed. Seventeen new soil map projects were started for Agriculture Canada and 14 for Environment Canada.

CanSIS–ARC–INFO. The Information Systems and Cartography Unit is now very much a part of CanSIS, as the custodians of the map (ARC) and soil (Info) files. Staff have been trained to use this new software and are converting maps from the old system. In addition, this year 673 requests for derived information plots were received and all were completed.

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R.C. Sinha, B.Sc., M.Sc., Ph.D., D.Sc., F.R.S.C.	Head of Section; Virus and mycoplasma vector relationships
L.N. Chiykowski, B.S.A., M.Sc., Ph.D.	Leafhopper-transmitted mycoplasmas
Y.C. Paliwal, B.S.A., M.Sc., Ph.D.	Aphid- and mite-transmitted viruses

Nitrogen Fixation

L.R. Barran, B.Sc., M.Sc., Ph.D.	Head of Section; *Rhizobium* ecological genetics
L.M. Benzing-Purdie,[4] B.Sc., M.Sc., Ph.D.	Carbohydrate chemistry
E.S.P. Bromfield, B.Sc., Ph.D.	*Rhizobium* ecology
Y.K. Chan, B.Sc., Ph.D.	*Rhizobium* physiology
F.D.H. Macdowall, B.Sc., M.Sc., Ph.D.	Legume physiology
R.W. Miller, B.Sc., Ph.D.	*Rhizobium* and legume physiology
R.J. Watson, B.Sc., M.Sc., Ph.D.	*Rhizobium* genetics
R.G.L. Wheatcroft, M.A., D.Phil.	*Rhizobium* genetics

Entomology

D.G. Harcourt, B.S.A., Ph.D., F.E.S.C.	Head of Section; Population dynamics and integrated pest management
J.C. Guppy, B.S.A., M.S.	Population dynamics
C.C. Loan, B.A., M.S., Ph.D.	Parasite–host relationships
F. Meloche, B.Sc., M.Sc.	Integrated pest management

Cereal Crops

V.D. Burrows, B.S.A., M.Sc., Ph.D.	Head of Section; Oat breeding
J. Frégeau, B.Sc., M.Sc., Ph.D.	Crop physiology
R.G. Fulcher, B.A., M.Sc., Ph.D.	Morphogenetics and grain quality
M.J. Morrison,[5] B.Sc.	Integrated crop management
K.M. Ho, B.Sc., M.Sc., Ph.D.	Barley breeding
D.R. Sampson, B.Sc., A.M., Ph.D.	Wheat breeding
W.L. Seaman, B.Sc., Ph.D.	Wheat pathology

Forage Crops

R.I. Hamilton, B.Sc., M.S.A., Ph.D.	Head of Section; Corn breeding
P.K. Basu, B.Sc., M.Sc., Ph.D.	Plant disease
A.T. Bolton, B.Sc., M.Sc., Ph.D.	Corn pathology
M.A. Faris,[6] B.Sc., M.Sc., Ph.D.	Legume breeding
A.R. McElroy, B.Sc., M.Sc., Ph.D.	Grass breeding
H.D. Voldeng, B.S.A., M.Sc., Ph.D.	Soybean breeding

Plant Gene Resources of Canada

B. Fraleigh, D.E.U.G., M.Sc., D.T.C.	Acting Head of Section

Electron Microscopy Service

R.C. Sinha, B.Sc., M.Sc., Ph.D., D.Sc., F.R.C.S.	Head of Section
G.H. Haggis, B.Sc., Ph.D.	Electron microscopy

Honorary Research Associates

D. Siminovitch, B.Sc., M.Sc., Ph.D., F.R.C.S.	Frost hardiness
F. Svejda, Ph.D.	Plant breeding
I.L. Stevenson, B.S.A., M.S.A., Ph.D.	Microbiology

Scientists on Contract

M.Dijak, B.Sc., M.Sc., Ph.D.	Cell genetics
J. Hattori, B.Sc., Ph.D.	Molecular genetics

C.V. Phan, B.Sc., M.Sc., Ph.D.	Cell genetics
D.H. Simmonds, B.Sc., M.Sc., Ph.D.	Cell genetics
T.C. Ta, B.Sc., M.Sc., Ph.D.	Biochemistry

VISITING SCIENTISTS

M. Asrat Ethiopia	Tissue culture
J.-Z. Deng People's Republic of China	Resistance to *Fusarium* sp.
J. Gabard, B.Sc., M.Sc. France	Molecular genetics
P.K. Gupta, B.Sc., M.S., Ph.D. India	Cereal cytogenetics
M. Hassin, B.Sc., Ph.D. Egypt	*Rhizobium* physiology
M. Mahoud, B.Sc., Ph.D. Egypt	Legume physiology
Y. Ohkawa, B.Sc., Ph.D. Japan	Cell genetics
D. Ou-he People's Republic of China	Soybean breeding
N. Ramaswany, B.Sc., Ph.D. India	Experimental haploidy
G. Shan, B.S.A. People's Republic of China	Soybean breeding
Z.-P. Tao People's Republic of China	Virus–mycoplasma interactions
P. Walton, B.Sc., M.Sc., Ph.D. Canada	Developmental physiology
Y.-Z. Wang People's Republic of China	Resistance to *Fusarium* sp.
H. Yi People's Republic of China	Plant gene resources
B. Yoo, B.Sc., M.Sc., Ph.D. Canada	Molecular genetics

Visiting Fellows, Natural Sciences and Engineering Research Council

S. Blakeley, B.Sc., M.Sc., Ph.D.	Molecular biology
Z. Fan, B.Sc., M.Sc., Ph.D.	Cell genetics
M. Gines, B.Sc., M.Sc., Ph.D.	Molecular genetics
S.M. Hemmingsen, B.Sc., Ph.D.	Molecular genetics
P.N. Kuriyan, B.Sc., M.Sc., Ph.D.	*Rhizobium* genetics
A. Laroche, B.Sc., M.Sc., Ph.D.	Freezing tolerance–gene expression
H. Le, B.Sc., M.Sc., Ph.D.	Cereal tissue culture
D. McCrae, B.Sc., Ph.D.	Biochemistry
P. Pechan, B.Sc., M.Sc., Ph.D.	Developmental physiology

V. Rastogi, B.Sc., M.Sc., Ph.D.	Genetics
R. Rutledge, B.Sc., M.Sc., Ph.D.	Molecular genetics
S.J. Symons, B.Sc., Ph.D.	Cereal quality
N. Thurman, B.Sc., Ph.D.	*Rhizobium* ecology

Graduate students

E. Armstrong, B.Sc.	Cereal quality
A.C. Bonfils, B.Sc.	Cell genetics
P. Charest, B.Sc., M.Sc.	Molecular genetics
F. Cosette, B.Sc., M.Sc.	Cereal cytogenetics
J. DeMoor, B.Sc., M.Sc.	Molecular genetics
D.A. Fielder, B.Sc.	Mycotoxin chemistry
C. Germain, B.Sc., M.Sc.	Cereal quality
K. Gibney, B.Sc., M.Sc.	Developmental physiology
G. Hoekstra, B.Sc., M.Sc.	Oat genetics
K. Hovey, B.Sc.	Cell genetics
J.E. Kendall, B.Sc.	Biosynthesis
R. Langis, B.Sc.	Cereal quality
R. Martin, B.Sc., M.Sc.	Agronomy
S.S. Miller, B.Sc., M.Sc.	Cereal quality
L.A. Morrisson, B.Sc.	Mycotoxin chemistry
V.B. Pentyala, B.Sc., M.Sc.	Developmental physiology
T. Reich, B.Sc., M.Sc.	Molecular genetics
A. Plourde, B.S.A., M.Sc.	Cereal cytogenetics
G. Saindon, B.S.A., M.Sc.	Soybean genetics
D.Y. Shafhauser, B.Sc.	Mycotoxin chemistry
A. Sproule, B.Sc.	Cell genetics
T. Villegas, B.Sc., M.Sc.	Developmental physiology

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[1] On leave to Professional Institute of the Public Service.

[2] Appointed August 1987.

[3] Seconded to Health, Safety and Security Division, Personnel Branch.

[4] Seconded to Priorities and Strategies Directorate.

[5] Appointed March 1984; on educational leave.

[6] Seconded to a Canadian International Development Agency (CIDA) program in Egypt.

INTRODUCTION

In 1987 the Plant Research Centre (PRC) developed an R&D strategic plan that outlines its mandate and research directions for the next 5–10 years. Three research programs, each headed by a program chairperson, were established: biotechnology, plant breeding and management, and plant–microbe interactions. Given the existing scientific expertise, resources, and facilities, PRC is establishing multidisciplinary teams that will focus their efforts on long-term strategically oriented research. A unique opportunity exists for a very productive integration of upstream research with applied research at the commodity level.

Past and proposed research activities were reviewed by external review panels in 1987. Their recommendations are being considered in the light of the new Research Branch directions in developing several establishment studies.

The integral role of biotechnology across the programs is significant. The utilization of emerging technologies is common to all program elements and is viewed as crucial to Canada's long-term strategic efforts to develop superior crop products for both domestic and export markets.

Notable research achievements in 1987 include the release of one soybean cultivar, one alfalfa cultivar, and nine corn hybrids; the establishment of technology to produce transgenic plants of canola (*Brassica napus*) by co-cultivation with *Agrobacterium tumefaciens*; the demonstration that gene products induced at low temperature in cold-tolerant wild species of Cruciferae are similar to those of *Brassica* crop species; the identification of wheat and corn germ plasm exhibiting tolerance to mycotoxin-producing *Fusarium*; the development of a method to isolate intact bacteroids of *Rhizobium* for biochemical and genetic studies; a parasitic European wasp *Dacnusa dryas* (Nixon) reduced to subeconomic levels the number of alfalfa blotch leafminer.

A remarkable feature of PRC is the extensive collaboration with industry, universities, provinces, and other national as well as international research organizations. This is reflected in the number of visiting scientists (13), visiting fellows (13), graduate students (22), and major collaborative research contracts with the industry and provinces (6). Finally, six biotechnology related workshops involving public and private sector participants were held in PRC in 1987.

PRC houses the National Office of Plant Gene Resources of Canada (PGRC), which is responsible for the preservation and exchange of genetic resources. Approximately 82 000 seed samples are currently stored. The PGRC supplies Canadian plant breeders with genetic resources, acts as repository for genetic resources developed in Canada, and plays a significant role in the international network of gene resource exchanges.

PRC is also responsible for the management of the entire Central Experimental Farm (500 ha), which includes the campus, arboretum, and ornamental gardens, and provides numerous services such as the indoor growth facilities, the vehicle fleet, campus security, assets management, and technical support.

This report summarizes only some of the more important research activities in 1987. Further information can be obtained from the publications listed at the end of this report. Reprints of the research publications and copies of this report are available on request from the Plant Research Centre, Research Branch, Agriculture Canada, Ottawa, Ont. K1A 0C6; Tel. (613) 995-3700.

Wolfgang Baier
Director

GENETIC ENGINEERING

Developmental plant physiology

The initiation and development of somatic embryos in petiole-derived callus of alfalfa (*Medicago sativa* L.) was optimized by medium component manipulation. More than 50 000 somatic embryos per gram of input tissue could be regenerated in 35 days; this system is being evaluated as a tissue culture propagation method for hybrid seed production.

Genotype selection, culture conditions, and donor tissue pretreatment were manipulated to optimize the production of somatic embryos in 35–50 days and is now being utilized in direct gene transfer studies.

Experimental haploidy

A detailed study of the early cellular changes during the induction of embryogenesis in isolated microspores of *Brassica napus* L. revealed that the process of induction occurred within the first few hours of culture of microspores at the late uninucleate and early binucleate stages of development. A genotype of *B. juncea* (L.) Czerniak. that consistently produced embryos from isolated microspore cultures was identified and experiments were initiated to increase the frequency of embryogenesis. Bud pretreatment by gamma irradiation was shown to substitute for high temperature treatment in the induction of embryogenesis in *Brassica* microspore cultures.

Somatic cell genetics

Two cell lines resistant to the herbicide chlorsulfuron were selected from mutagenized microspore cultures of *B. napus* 'Topas'. Biochemical analyses provided evidence for the presence of a resistant enzyme system; plant regeneration experiments were initiated. An *Arabidopsis thaliana* (L.) Heynh. plant demonstrating potential resistance to the herbicide glufosinate was selected from mutagenized seeding populations.

Morphological and biochemical analyses of somatic hybrids between *B. napus* L. and *Diplotaxis harra* (Forssk.) Boiss. were continued and the inheritance of organelles among these hybrids was followed by chloroplast DNA restriction analysis and mitochondrial protein analysis.

Cell cultures of wild cruciferous species, including flixweed (*Descurainia sophia* (L.)), stinkweed (*Thlaspi arvense* L.), shepherd's-purse (*Capsella bursa-pastoris* (L.)), and *Arabidopsis thaliana* L., were established and protoplast isolation and culture methodology developed for application to somatic hybridization studies. Plant regeneration was consistently achieved from cell cultures of *A. thaliana*, thereby offering a new approach for achieving transformation in this important model species.

Experiments to transfer mitochondria between *Brassica* species by microinjection were continued. Intracytoplasmic microinjection of *B. napus* 'Jet Neuf' protoplasts was achieved and injected protoplasts divided to produce colonies. The biochemical basis of cytoplasmic male sterility in *B. napus* was studied by *in organello* mitochondrial protein synthesis; preliminary results revealed mitochondrial protein differences between sterile and fertile lines.

A project aimed at transferring frost tolerance from *Solanum lycopersicoides* into the cultivated tomato *Lycopersicon esculentum* by protoplast fusion was initiated; cell suspensions of various tomato genotypes were initiated and methodology for protoplast isolation and culture established.

Protoplasts isolated from leaves of several *Nicotiana* species that had been transformed with antibiotic resistant genes were cultured in a range of antibiotic concentrations. Protoplasts from transgenic plants demonstrated significantly increased tolerance to the appropriate antibiotics, thereby establishing a potential new approach for selecting somatic hybrids.

Plant molecular genetics

The production of transgenic canola (*B. napus*) by *Agrobacterium*-mediated transformation was accomplished and genetic analyses completed. The transgenic plants were fully fertile and morphologically indistinguishable from normal canola plants. Transgenic tobacco lines were also produced by *Agrobacterium*-mediated transformation. Genes isolated from *Arabidopsis* were reconstructed and introduced into tobacco. Selective herbicide resistance and cross resistance to a number of other herbicides was achieved. The genetic engineering of herbicide resistance in canola was undertaken.

High levels of mammalian metallothionein were expressed in turnip (*B. campestris* L.) plants, using cauliflower mosaic virus vectors. Analyses of cadmium (Cd) binding showed that expression was associated with the complete depletion of free Cd in the infected plants. Strategies for employing this gene for crop protection to heavy metal pollutants are being explored.

Molecular genetic analysis of cereals using restriction fragment length polymorphisms was initiated collaboratively. Ribosomal DNA showed polymorphism in barley and 24 related wild *Hordeum* species, establishing five groups of phylogenetically related species and demonstrating the uniqueness of *H. bulbosum* L.

CYTOGENETICS

Cereal cytogenetics

A genetic system is present in hexaploid wheat (*Triticum aestivum* L.) that restricts chromosome pairing to homologues and thus prevents pairing of homoeologous chromosomes in wheat itself or in intergeneric hybrids. The diploidizing system is oppositional in nature, having both genes that promote pairing and others that suppress pairing. With the exception of the *Ph* locus on chromosome 5B, the other factors with minor effects are spread over numerous chromosomes. Some diploid species such as rye (*Secale cereale* L.) have genetic mechanisms that suppress the meiotic pairing control system of wheat. The chiasmata frequencies were studied in the progeny obtained from pollinating wheat cultivar Chinese Spring with F_1 populations from Petkus × Prolific rye and Prolific × Puma rye. In the former populations the chiasmata frequencies indicated a segregation for genes with major effects, possibly acting in a complementary fashion. The progeny from the second cross showed a continuous distribution, indicating meiotic pairing being affected by numerous genes with minor effects. Thus the genetic control of meiotic chromosome pairing in the two cultivars was quite different. Five spontaneous partial amphiploids with chromosome numbers $2n = 35, 36, 36, 38$, and 41 were obtained from the same wheat and F_1 rye hybridizations. The origin of these amphiploids was attributed to duplication of a portion of the wheat complement after fertilization.

Molecular cytogenetics

Giemsa karyotypes for three accessions of *Hordeum chilense* Rhoem & Schult. from South America were described. The seven chromosomes of all three accessions could be identified on the basis of length, arm ratio, and distribution and strength of giemsa C-banding. At least five pairs could not be identified without the aid of C-banding. The three accessions were not identical in C-banding pattern. Each chromosome showed polymorphism for C-bands, particularly terminal bands and to a lesser extent interstitial bands. However, the similarities still allowed the identification of homoeologous chromosomes in the various accessions. An image analysis program that printed chromosomes in a straightened form greatly aided in the identification of the banded chromosomes.

The nucleolus organizers (NORs) of *Thinopyrum distichum* (Thunb.) Love ($2n = 28$) are suppressed in the amphiploid of *Triticum durum* × *T. distichum*. Silver nitrate-staining demonstrated a maximum of only four nucleoli and giemsa C-banding indicated that these were formed by chromosome 1B and 6B of wheat. In situ hybridization with the ribosomal DNA probe pTa 71 followed by backcross analysis has shown that only one of the seven addition lines with *T. distichum* will be identifiable with the probe.

Developmental biology

Environmental treatments of wheat donor plants were shown to influence the androgenic response of cultured anthers. Maintaining donor plants at low temperatures (10° day–5°C night), for 4 weeks prior to the isolation of anthers, resulted in a substantial increase in yield of embryogenic calli and also allowed a wider range of genotypes to respond to in vitro induction.

Methodology was established for isolating protoplasts from wheat cell suspension cultures. Fast-cycling cultures were selected from somatic and microspore-derived calli of both winter and spring cultivars.

Spike development can now be studied and modified under in vitro conditions. Spikes containing florets at the stage of initiation of floral primordia were cultured until the completion of floral development. Microsporogenesis occurred under in vitro conditions and mature pollen was isolated from the anthers.

STRESS PHYSIOLOGY

Biotechnology

Wild species of the Cruciferae family were screened for their ability to develop freezing tolerance with the eventual objective of gene transfer into the cultivated species. Leaves of *Descurainia sophia* (flixweed), *Thlaspi arvense* (stinkweed), *Barbarea vulgaris* (yellow rocket), and *Arabidopsis thaliana* were all able to develop freezing tolerance; flixweed was the most hardy. Induction of polypeptides of 15, 20, and 27 kD was observed during hardening in *Arabidopsis*, flixweed, and *Brassica napus*. These polypeptides may be associated with the cold-hardening process in the Cruciferae.

Embryos were successfully obtained from isolated microspores of a winter *Brassica napus* 'Jet Neuf'. Freezing tolerance was induced in these embryos by a combination of low temperature (2°C) and abscisic acid (5×10^{-5} *M*), whereas embryos derived from Topas (a spring type) were unable to develop freezing tolerance under similar treatment. The potential for using the ability of embryos to cold harden as a test for screening freezing-tolerant genotypes of winter *Brassica* is under investigation.

A project was initiated to investigate lipid biosynthesis during the early stages of development of microspore-derived embryos of *Brassica* sp. Changes in culture conditions markedly affected growth and development of embryos, but they generally did not significantly alter fatty acid composition of the storage lipids. Major changes in fatty acid profiles were observed during the early stages of embryogenesis. In the zero erucic acid cultivar, Topas, fatty acid composition of embryos remained relatively constant after 14 days in culture and was similar to that observed in mature seeds. In Reston, a high erucic acid cultivar, erucic acid did not accumulate significantly until 14 days in culture, and the level of erucic acid continued to increase gradually for several more weeks.

A low temperature anaerobic hardening response in winter wheat, in which a flooding exposure increases tolerance to a subsequent ice encasement stress, was further described by increases in three glycolytic enzymes occurring after low temperature flooding. This accelerated glycolysis was accompanied by substantial increases in total adenylates and adenylate energy charge, and these elevated levels were maintained throughout the subsequent ice encasement period. Winter barley, which does not show the anaerobic hardening effect in similar conditions, did not show similar increases in two of the three enzymes after flooding, and did not maintain high levels of adenylates throughout ice encasement.

Field trials and screening

Winter survival of cereals at Ottawa was generally good with survival of normally planted wheat at about 95%. Ice encasement of a field plot reduced survival markedly, but a number of cultivars from both the soft white and soft red coop tests survived at approximately 30%, demonstrating a significant improvement over standard cultivars. Late planting of winter wheat once again allowed greater survival of soft white wheats under severe ice encasement conditions.

Diseases

A number of species of *Typhula* were demonstrated to be snow mold organisms, which reduce winter survival of overwintering cereals. Three species of *Typhula* were tested for their ability to colonize nonliving host substrates and it was shown that all three can behave saprophytically on field and greenhouse plant tissue. These three common pathogens as first colonizers can dominate the substrate to the extent of inhibiting penetration by other soil-borne fungi. They can also compete successfully for substrate precolonized by other saprophytic fungi. In total, the three *Typhula* species can compete successfully in both the soil environment and in host tissues for the nutritional base required for sclerotial development.

The severity of pathogenesis induced by strains of barley yellow dwarf virus (BYDV) has been shown to determine the magnitude of the changes in response to the virus in carbohydrate fractions, cellular permeability, and ion uptake of winter wheat crown and leaf tissue, at both cold-hardening and normal growth temperatures. Relationships between these changes and the interference of BYDV with normal plant response have not yet been established.

MYCOTOXIN

Further experiments have been done to understand the difference in tolerance for *Fusarium graminearum* metabolites between cells of *Fusarium* head blight resistant and susceptible wheat cultivars. Medium scale fermentations of wheat cells have been developed in a low-shear fermentor, involving the addition of ^{13}C-DON (deoxynivalenol) and ADON (3-acetyldeoxynivalenol), as well as ^{14}C-DON. These experiments have demonstrated that the fungal toxins are metabolized and the identification of the degradation products is currently under way. Using the poly-U ^{14}C-phenylalanine incorporation test, ribosomes of susceptible varieties were shown to be sensitive to DON. Preliminary data appear to show that ribosomes from a *Fusarium* head blight resistant cultivar are less sensitive. This suggests an additional means by which resistant cultivars can limit the effects of the trichothecene mycotoxins. The in vitro test for *Fusarium* head blight resistance has been used to demonstrate that in the F_3 progeny of a toxin-tolerant resistant cultivar and a toxin-intolerant susceptible cultivar some of the progeny are resistant.

New work has been done on *Fusarium graminearum* disease in corn. Suspension cultures of a number of inbreds were derived through tissue culture and the effects of *F. graminearum* metabolites on protein synthesis studied. Field tests of 26 inbreds and 26 hybrids for resistance to maize ear rot was done and there was a correlation between in vitro response of suspension cultures to toxins and the field data.

Nuclear magnetic resonance (NMR) has been used to determine the absolute configuration of the trichothecenes and other sesquiterpenes produced by *Fusarium* species, with a view to understanding the specific structural configurations associated with their toxicity. ^1H NMR of 36 natural and synthetic trichothecenes were studied and correlated with their conformation. The data showed that the trichothecene molecules adopt the most stable conformation in solution. Nuclear Overhauser effect difference spectra were also used to establish the stereochemistry of the sesquiterpene metabolites ring systems. Trichothecenes have a *cis*-fused ring A/ring B, as opposed to those of sambucinol and apotrichothecene which are *trans*-fused rings.

Approximately 400 mg of ^{14}C-enriched deoxynivalenol (DON) (0.94 μCi/mg) was prepared in collaboration with the Animal Research Centre and is being used in both plant and animal studies. High radioactivity was ensured by using enriched acetate as a simple precursor in a large-scale fermentation of *F. culmorum*.

The detoxification of DON by plants *via* conjugation was studied. Fatty acid (stearic, oleic, linoleic, and linolenic) esters and the glucosides of DON were synthesized as possible contaminants of animal feed made from contaminated grains. The toxicity of these compounds was determined and found to be 10–20 times less than that of DON. High-performance liquid chromatography (HPLC) analysis of DON-contaminated wheat showed the presence of a DON glucoside. The synthesis of other sugar conjugates of DON is being done.

Some 31 minor metabolites have been isolated from *Fusarium sporotrichioides*. They include a number of apotrichothecene derivatives. Although these compounds are not toxic, interest in them stems from the fact that some are common to the other *Fusarium* species examined in our studies. Hydroxyapotrichothecene was found to readily undergo rearrangement and oxidation in ethyl acetate to give six compounds, which have been detected in the crude fungal extract by gas chromatography–selected ion monitoring but not previously isolated. Enniatins were isolated from the mycelium of *Fusarium avenacium*. The ability of other *Fusarium* species to produce these mycotoxins is being assessed, and the possibility of their presence in animal feed determined. The enniatins are known to be phytotoxic.

PLANT PATHOLOGY

Mycoplasma diseases

Transmission of the eastern peach × mycoplasma (PXM) by *Paraphlepsius irroratus* was affected by age of plant, length of inoculation access period, and inoculation host species. In host range studies, 21 plant species in 10 families were shown to be new hosts of PXM, bringing the total number of plants known to be susceptible to 41 species in 15 families. Infection of species in Boraginaceae, Caryophyllaceae, Geraniaceae, Onagraceae, and Gramineae constitutes the first report of the susceptibility of these families to the mycoplasma. The susceptibility of the family Gramineae may be of some significance in the epidemiology of peach-X disease because grasses are often used as ground cover in orchards. Use of a species that is susceptible to PXM and that is also a developmental host of the vector could provide an important source of disease inoculum. *P. irroratus* leafhoppers were able to acquire and transmit the mycoplasma from a wide range of plant species, but the number of insects that became inoculative varied considerably both among plant species and among plants within a species. The relative concentration of mycoplasma antigens in several herbaceous hosts, as determined by enzyme-linked immunosorbent assay (ELISA), was not always correlated with the capacity of plants to serve as source hosts for mycoplasma acquisition by the leafhoppers. The mean incubation period of the mycoplasma in the leafhopper was temperature dependent, varying from 54 days at 21°C to 32 days at 28°C. The transmission pattern by inoculative leafhoppers following completion of the incubation period was erratic. Storing infective leafhoppers at -70°C was shown to be an effective method of preserving PXM for 6 years, the longest time tested. An Ottawa isolate of PXM was less efficiently transmitted by *P. irroratus* than was an isolate from Harrow, Ont., but the difference was not always significant. Injection of leafhoppers with inoculum of the two isolates resulted in the same level of transmission, suggesting that the difference in transmission of the two isolates was due to the effect of environmental conditions and source plant species on pathogen availability to the leafhopper. Direct ELISA tests of the two isolates indicated that they are closely related serologically.

Virus diseases

A survey of cocksfoot mild mosaic virus (CMMV) in 22 wheat fields in 13 counties of Ontario showed the virus to be present in 13 fields in 10 counties with incidence ranging from 3.5 to 19%. Wheat and triticale cultivars were screened for their reaction to CMMV. Thirteen of 18 winter wheats were susceptible (15–100% infectible plants) and five were resistant (hypersensitive). Six of 12 spring wheats were susceptible and all four triticale cultivars tested were highly susceptible. CMMV infection in Augusta wheat and *Trillium* triticale plants caused delayed flowering as well as a reduction in fertile tillers, plant height, biomass, and kernel weight.

A method for purifying subclover mottle virus (SCMOV) was developed, using the plant host *Trigonella*. A specific antiserum was prepared and two rapid diagnostic tests standardized. SCMOV showed no serological relationship to six other legume viruses except a one-way reactivity to lucerne transient streak virus. The ability of the viroid-like ribonucleic acid (RNA) of SCMOV to undergo heterologous replication directed by southern bean mosaic virus was established but the pathogenicity modifying property was not detected on the hosts examined.

NITROGEN FIXATION

Ecology

Research focused on the nature of indigenous *Rhizobium* populations, a major ecological constraint to the establishment of inoculant strains. Relative to four commercial strains, phage types representative of two indigenous *Rhizobium* populations showed a high level of effectiveness. On the basis of plasmid number and mass, 160 isolates comprising 45 and 48 types from both sites were placed in 22 different groups with 17 and 13 groups from the respective sites. The number of plasmids varied between one and five per isolate with molecular masses ranging from five MDa to considerably greater than 267 MDa. Five isolates lacked a plasmid band with mobility in agarose gels corresponding to that of the megaplasmid band of reference strain *R. meliloti* SV47, but they showed instead a band of much greater molecular mass. Phage types which were divided into plasmid groups solely on the basis of differences between isolates from each site may reflect adaptation of *R. meliloti* to their respective sites. Differences between isolates within certain phage types due to the presence or absence of a single plasmid may have resulted from genetic interchange between indigenous *R. meliloti*. There was no significant correlation between plasmid number and mass and symbiotic effectiveness or phage sensitivity of the phage types from either site.

Deoxyribonucleic acid (DNA) probes for common nodulation (*nod*), host specific nodulation (*hsn*), and nitrogenase structural (*nif*) genes hybridized to cryptic plasmids of indigenous *R. meliloti*. Of thirty phage types tested, 15, 4, and 1 contained cryptic plasmids that hybridized to the *hsn*, *nif*, and *nod* gene probes, respectively. This is the first report of reiterated symbiotic genes on cryptic plasmids of *R. meliloti*, and the significance of this finding for symbiotic nitrogen fixation and nodulating competitiveness is being investigated.

Rhizobium physiology and biochemistry

A method was developed for the isolation of functionally intact bacteroids from alfalfa nodules. These bacteroids with respiration-supported nitrogenase activity were shown to utilize only trichloroacetic acid (TCA) cycle dicarboxylic acids to generate a low potential reductant required by the nitrogenase enzyme system. The bacteroids showed no detectable megaplasmid but retained megaplasmid-borne sequences. Bacteroid differentiation involved structural and compositional alterations in the lipid bilayers of the cytoplasmic membrane. Transmembrane potentials of bacteroids were 75 mV more negative than those of free-living *R. meliloti* cells. The terminal oxidase of the bacteroids was altered and cytochrome *a* content of the respiratory membrane was greatly reduced compared to free-living cells. The adenylate energy charge factor of bacteroids and nodules increased as the temperature was lowered from 30 to 5°C. Purified nitrogenase has little catalytic activity below 10°C, whereas nodules and bacteroids maintain significant activity to 5°C and below. The Q_{10} for the isolated nitrogenase was five, whereas that of the in vivo system was 1.5.

Unconventional nitrogenases have been found in nitrogen-fixing bacteria of several genera, including *Azorhizobium* and *Pseudomonas*. The unique production of ethane from acetylene was applied as a diagnostic test for the presence of unconventional nitrogenase systems.

Rhizobium genetics

A Fix^- Tn5 mutant of *R. meliloti* was shown to be defective in C_4-dicarboxylic acid tansport (*dct*). The *dct* genes were mapped to a 4-kb segment of DNA on the exomegaplasmid. Tn5 mutagenesis in this segment of DNA revealed the presence of three loci. Mutations in one locus gave Fix^- mutants, whereas mutations in the other two loci resulted in partial Fix^- phenotypes. A number of symbiotically ineffective Tn5 mutants of strain JJ1c10 that overproduce exopolysaccharides were isolated. These mutants are being arranged in complementation groups.

The insertion sequence IS*Rml* was identified and characterized in *Rhizobium meliloti* JJ1c10. An internal part of the sequence was cloned and used as a probe to show the wide distribution of IS*Rml* in *R. meliloti* and its occasional presence in other species of soil bacteria. The hybridization patterns made with restriction fragments of the DNA from various *R. meliloti* strains formed the basis of an identification method now being used to identify competing strains in the developing root nodules of alfalfa.

Alfalfa physiology and biochemistry

Newly synthesized photosynthate is translocated to the nodules within 30 min and is preferentially utilized by the nodules, but stored carbon compensates in the dark and increases with successive growth cycles. CO_2 fixed in the nodules provided about 12% of the carbon required for nitrogen assimilation. CO_2 enrichment of the root environment did not increase symbiotically supported plant growth. The pathway of nitrogen assimilation from fixed nitrogen in nodules was not disturbed by nitrate concentrations inhibitory to nodule growth. The principal soluble product (up to 80%) of nitrogen assimilation is asparagine. Asparagine synthetase showed maximal activity in 17-day-old plants.

Inhibitory effects of acetylene on its own reduction and on respiration varied with cultivar, strain, and growth temperature. The maximum rate of reduction of acetylene by nitrogenase in nodulated roots occurred at about 10 min from the start of the assay with 10% acetylene. Acetylene reduction by nitrogenase in nodulated roots is insensitive to temperature between 5 and 15°C when plants are grown at 10°C.

ENTOMOLOGY

Population dynamics and integrated pest management (IPM)

Alfalfa weevil. Populations in the dairy belt of eastern Ontario declined for the second successive year, falling to their lowest levels since 1984. However, computerized tracking of weevil and crop phenology in the bellwether Bay of Quinte area during early spring revealed an alarming discrepancy in favor of weevil development. This was confirmed by integrated pest management (IPM) scouts who found threatening levels of tip-feeding prior to the early bud stage in about one-third of all fields under surveillance. Grower alerts resulted in early harvest of about 40 000 ha of first-cut alfalfa, and less than 1000 ha were treated with pesticides. Life table data from several sites in the Quinte area revealed that disease infections caused by *Erynia* spp. killed 81% of the feeding larvae and 31% of the cocooned stages. These levels of mortality were about average, but numbers of the euphorine parasites *Microtonus aethiopoides* Loan and *M. colesi* Drea were subnormal, possibly as a result of the increased use of pesticides in 1985 and 1986, and their combined rates of attack fell by 40%. As a result, the overall rate of weevil survival increased to 4.6%. This foreshadows a moderate upturn in weevil populations for 1988.

A 3-year field study on the biology of *M. aethiopoides* showed that significantly more female than male adult weevils were attacked in May by first-brood parasites. This would tend to increase parasite efficiency. However, peak egg production by the host preceded the peak of parasite attack, and even very high rates of parasitism were insufficient to constrain populations of the weevil. Regression of date of emergence of insectary-reared parasites on accumulated degree-days (DD), base 9°C from 1 April, showed that peak numbers of second-brood adults emerged in June at 350 DD, preceding emergence of summer weevils by 8–15 days. The attack by this brood was completed in July at 550 DD. A small proportion of reproductive summer weevils was attacked by a partial third brood of the parasite during late August and September.

Alfalfa blotch leafminer. Populations have now declined to subeconomic levels in southern Ontario. This is attributed to a concerted program of classical biological control in which the exotic parasite, *Dacnusa dryas* (Nixon) was imported, propagated, and systematically released. *D. dryas* has three generations a year that correspond seasonally to those of its host. It overwinters as a mature larva within the leafminer puparium, resumes its development in the spring, and emerges about 10 days after its host. Coincidence of wasp flight and hatch of leafminer eggs is high in all three generations. This host–parasite synchrony results mainly from a sequence of three events during the host–parasite life cycles: lack of development of the parasite beyond the first instar within the host larva; a temperature-dependent rate of development of the subsequent stages, which is similar to that of the host pupa; and different overwintering strategies, which result in the parasite emerging later than its host to sustain the relationship.

Alfalfa snout beetle. The alfalfa snout beetle, which was first discovered in mainland Ontario in 1986, has a 2-year life cycle and the adults migrate in even years. A smaller but equally well established brood was discovered in 1987. In field surveys, larvae of this brood were detected on 10 farms in a 12-km^2 area of south Grenville County. This doubles in size the previously recognized area of distribution and suggests that the pest has been present in the area for a number of years.

CEREAL CROPS

Oats

Breeding. Tibor naked oat is gaining popularity with farmers and has performed well both as a feed for pigs and poultry and as a processing oat for human food. It has the energy content of corn combined with a protein quality almost equal to that of soybean meal, making it an attractive "on the farm" feed. Protein content is in the correct range (14–19%) for grower diets, but feed formulators may wish to add lysine and methionine to the diets at the same time they add vitamins and minerals to obtain maximum animal performance. Tibor may serve a very useful role for feed in cooler climates where neither corn nor soybeans can be grown successfully.

Quaker Oats of Canada Ltd. conducted for the first time a large-scale (50 t) evaluation of Tibor in their Ontario processing plant and encountered no major problems in making conventional oat products. Hull-less genes are not expressed completely in naked varieties (5–8% covered seeds in Tibor), but a new daylength insensitive, awned, oat OA753-2 (03669) produced only 0.4% covered seed which has attracted the interest of Robin Hood Multifoods and they have begun a commercial evaluation.

Registration of the new variety OA774-1 is being sought because it is equal to the popular variety Donald in performance but is resistant to the new races of crown rust in Ontario.

Grain quality. Digital image analysis was used to assess genetic and environmental control of milling quality in oats. This will continue in a collaborative research program with industrial partners. A project was also initiated to evaluate genetic and environmental influences on mixed linkage β-D-glucans in oat kernels.

Pathology. Crown rust is one of the most important diseases of oats in Ontario. The cultivar OAC Woodstock, which contains the resistance gene *Pc39*, has, until recently, been the only moderately early cultivar adapted to Ontario to provide effective resistance to crown rust. In 1987, several commercial fields developed moderate to severe crown rust infections. The development and rapid spread of a race of *Puccinia coronata* virulent on Woodstock is related to crown rust's ability to cycle on the alternate host, common buckthorn (*Rhamnus cathartica* L.). The expected loss of Woodstock and the alarming rate at which new races are appearing indicate the urgent need for development of new crown rust-resistant oats for Ontario. Progress is being made in identifying advanced breeding selections resistant to the two most prevalent races, *Pc38* and *Pc39*.

Septoria (*Septoria avenae* Frank f. sp. *avenae*) is another important disease in eastern Canada but breeding for resistance has been largely unsuccessful over many years. A new PRC tolerant selection O2540-3-7 has been identified at both Charlottetown (1984 and 1985) and at Ottawa (1984–87).

Physiology. A 5-year study on ways to manage the dormancy behavior of dormoats to improve spring emergence was concluded. Seed behavior of dormoats in the field was found to be sporadic and unpredictable. Responses were complex and achieving field predictability was difficult, because laboratory studies cannot duplicate complex field seedbed-environments. Artificial induction of secondary dormancy prior to planting was not successful in improving spring emergence over non-treated seeds, even though a high level of laboratory dormancy was induced in some lines. The concept of manipulating the dormancy status of a line to achieve better spring emergence needs to be reexamined. Dormoats seem to lack sufficient winterhardiness because a high percentage of ungerminated seeds was lost over winter. Hybrids involving dormoat × winter-type parents have been made and the progeny are now being tested to determine if spring emergence is improved.

Wheat

Breeding. Eighty-five percent of the nursery was devoted to soft white winter pastry-quality wheat, with the remainder devoted to hard red winter bread wheat. Three problem areas have top priority: preharvest sprouting resistance (21% of the nursery), winter survival (18%), and resistance to head blight caused by *Fusarium graminearum* Schw. (11%). Crosses made to incorporate powdery mildew (*Erysiphe graminis* DS ex Mérat) resistance accounted for 18% of the 1987 nursery, those for loose smut (*Ustilago tritici* (Pers.) Rostr.) resistance made up 10%, and for leaf rust (*Puccinia recondita* Rob. ex Desm. f. sp. *tritici*) resistance, 9%. The 1987 season also permitted efficient selection for powdery mildew, leaf rust, and lodging resistance. Testing for survival under ice indicated 52 superior lines, which were subsequently entered in yield trials. Large F_2 populations were harvested that are expected to combine genes from our best two sources of sprouting resistance with pastry quality. One F_2 line had almost as good *Fusarium* head blight resistance as the parent Frontana.

Quality. Joint studies with industry showed the usefulness of fluorescence imaging-based procedures for bran determination in commercial mill streams. Using digital image analysis, a program was begun to define tissue relationships in wheat kernels with varying milling characteristics. Two programs were begun in 1987 in collaboration with the University of Ottawa: (*1*) electrophoretic evaluation of specific proteins in types A and B wheat starch granules, and (*2*) biochemical determination and localization of mixed-linkage β-D-glucans in wheat grains and vegetative tissues.

Pathology. Snow mold damage was lighter than usual in most areas but moderate to severe in isolated fields in Simcoe County and the eastern counties. *Typhula* spp., including *T. phacorrhiza* Reichard ex Fries, were associated with most of the damage. Screening for resistance to snow mold was continued in the field. Eighty-two advanced lies of wheat proved to be resistant to two races of loose smut (*Ustilago tritici* (Pers.) Rostr.).

Physiology. Entries in the Ontario winter wheat screening and cooperative tests were evaluated for preharvest sprouting resistance. Fredrick and Harus, although susceptible, showed the best performances and Gordon showed the poorest performance among the commercial cultivars. A study on wheat grain development in relation to sprouting behavior was conducted with field grown material. Embryos were excised at different times throughout development and put in culture with or without abscisic acid (ABA); embryonic germination was inhibited more effectively by ABA in sprouting tolerant–resistant cultivars. However, the extent of the response was linked to the environmental conditions during grain development.

Barley

Breeding. The PRC cultivar Léger is the new standard for yield and adaptability of barley in eastern Canada. A new mildew-resistant strain, OB942-1, which obtained mildew resistance from a two-row barley, has been entered in the six-row barley cooperative test. Two new strains, OB751-12 and OB751-27, out-performed check varieties Rodeo and Birka in the 2nd year of the two-row cooperative test. Somaclonal variation experiments were done on five cultivars (Bruce, Léger, Rodeo, Mingo, Multum) of barley. Calli were induced from the immature embryos and plants regenerated. Only a few variants were found in the field from 536 regenerated plants.

FORAGE CROPS

Corn

The 1987 growing season was long and above normal in heat unit accumulation. Severe to minor moisture deficits occurred at different evaluation locations.

Nine hybrids were supported for licensing: four for the Atlantic region, (OX738, OX739, OX759, OX810); one for Quebec (OX837); two for the 2700–2800 corn heat unit (CHU) zone of Ontario (OX780, OX805); and two for the 2200–2275 CHU zone of Manitoba (OX783, OC828).

Cooperative studies with breeding programs at Lethbridge, Brandon, Morden, Saint-Jean-sur-Richelieu, L'Assomption, and the universities of Guelph and Manitoba identified new heterotic patterns for extremely early (2000 CHU) and high-yielding (6.2 t/ha) hybrids with good agronomic properties. Similar studies in the Maritimes (Charlottetown and Fredericton) have identified potentially adapted hybrids. These hybrids will enable a comparison of corn as a feed grain and/or alternate crop on a significant hectarage in a feed-grain deficient region.

Work has continued on the identification of elite lines of grain corn that germinate and grow well at low temperatures. A first trial during summer 1987 of four populations germinated at 9°C, then grown 4 weeks at low temperature in a growth chamber indicated that superior germination and vigorous growth were not always linked. Data from control and selected populations from a first cycle of selection for good low temperature growth lead us to believe that progress toward improved low temperature growth has been made in the first cycle.

Pathology. As a result of a comparatively dry season in Ontario in 1987, damage from ear mold was much less severe than it was in 1986. However, the disease was present in 43 of 43 fields examined during a survey in September. Field inoculation experiments confirmed that differences in susceptibility to ear mold caused by *Fusarium roseum* var. *graminearum* (Schwake) Snyd. & Hans., exist among the hybrids commonly grown in eastern Ontario. A search for resistance to the disease among inbred breeding lines resulted in one line out of 25 tested exhibiting a high degree of tolerance. High tolerance also was present in the progeny of the F_1 between this inbred and very susceptible lines.

In a survey of corn fields in Ontario in 1987, Stewart's disease, caused by *Erwinia stewartii* (E.F. Sm.) Dye, was observed in several locations across the province. This indicated that the disease had spread considerably from the 1986 locations. Anthracnose (*Colletotrichum graminearum* (Ces.) G.W. Wils.) occurred at several locations (15 of 43) in southern Ontario from Windsor to Picton.

Grasses

The forage grass program is focused on the development of grass cultivars with significantly improved feeding value, and on the genetics and breeding behavior of autopolyploid forages.

Forage quality is reduced by enzymatic degradation of protein during ensiling. A preliminary investigation revealed genetic variation for the amount of proteolysis in timothy, and suggested that it may be possible to reduce this protein loss by breeding. Rapid screening techniques are now under study.

The necessity of using intense interplant competition when selecting timothy plants for yield was underlined in a 2-year study. Plants chosen for outstanding vigor in spaced nurseries gave a wide yield response in simulated swards (100 plants per square metre) and some genotypes were completely eliminated. The precision of yield and quality estimated were determined for three simulated sward planting patterns.

A series of computer programs was developed to determine the genotypic structure of autopolyploid progeny populations. These programs are being used to investigate the level of heterozygosity at multiallelic loci in autopolyploids and to develop genetic models. Crosses can be made between individual genotypes or populations, or populations can be advanced for any number of synthetic generations.

Switch grass (*Panicum virgatum*), a C_4 forage grass, grows better in eastern Ontario than currently used forage species under hot dry midsummer conditions. Low temperature tolerance expressed as LT_{50} increased rapidly during the second half of October from -3°C to between -19 and -24°C in the years 1985–1987. It is concluded that switch grass would be persistent in eastern Ontario, and this has been supported by its good survival during the past four winters in the nursery.

Soybean

Breeding and genetics. Line OT84-12 was registered as Maple Glen and Breeder Seed distributed to producers by SeCan Association. Elite seed producers have reported excellent results with this cultivar, confirming yield trial results which show yields 10% higher than Maple Arrow. Line OT85-5 was supported for registration by the Ontario Oil and Protein Seed Crops Committee. This is an early maturity line (2450) and should replace such cultivars as McCall and Maple Isle. Line OT85-5 is a BC_3 selection of the cultivar Evans (E_3 selection) with the earliness and photoperiod insensitivity gene e_4 from the Swedish line 840-7-3, which makes the line 2–3 weeks earlier than the recurrent parent Evans. Two small-seeded natto type lines, OT84-3 and OT85-8, have higher yield, slightly smaller seed size, and very much lower levels of seed coat impermeability than Canatto. They are considered acceptable for natto production in Japan and will be released to SeCan Association. Genetic studies have confirmed that insensitivity to long photoperiods, defined as little or no delay in flowering, pod set, or maturity, is controlled by two gene pairs, $E_3\,e_3$ and $E_4\,e_4$, with both recessive genes necessary for insensitivity.

Pathology. A survey to determine the importance of soybean brown spot (*Septoria glycines* Hemmi) disease in eastern Ontario showed that about 84% of the fields (63 of 75) were infected at a low to moderate level of severity. Three fields had sufficient infection to cause yield reduction. Field plot experiments indicated that this disease has the potential to cause significant (9–15%) yield losses. A search for resistance to this disease is under way.

Alfalfa

The new alfalfa synthetic, Olinda, was licensed in October 1986. It has 70% resistance to phytophthora root rot (PRR), *Phytophthora megasperma* Drechsler f.sp. *medicaginis*. It shows reduced seedling stand losses and increased productivity in older stands during prolonged wet periods. Plants are uniform, with high feed value and quick recovery after cutting. Seed has been released to pedigree seed growers and will be available to farmers in 1988. A second alfalfa synthetic, Comsel, was licensed in November 1987. It has 82% resistance to PRR. These two synthetics have the highest resistance to PRR of any Canadian-developed alfalfas.

Seed production from a large polycross population selected for bacterial wilt (BW), *Corynebacterium insidiosum* (McCull) H.L. Jens, and verticillium wilt (VW), *Verticillium albo-atrum* Reinke & Berth., has been completed and further screening of these progeny will be conducted to select plants with high resistance to BW, PRR, and VW for the production of alfalfa synthetics.

Differences in cultural requirements, morphology, and pathogenicity, together with electrophoretic evidence from 26 isolates of presumed *Phytophthora megasperma* Drechsl. f. sp. *medicaginis*, have indicated there are likely two distinct species of *Phytophthora* attacking alfalfa in this region.

Research on nitrogen transfer from alfalfa to various grass species under field conditions (using the ^{15}N dilution technique) indicated that early-maturing grass species benefit more than late-maturing species.

Experiments on the metabolism of N fixed by alfalfa indicated that NH_3 produced from N_2-fixation was primarily assimilated into glutamine and glutamate by the catalysis of glutamine synthetase–glutamate synthase. Glutamate is then transaminated to a range of amino acids including aspartate, which is subsequently amidated using the amide of glutamine to produce asparagine, a final product to be transported to the shoot for plant growth.

Pathology. Verticillium wilt of alfalfa has become established in most counties of eastern

Ontario. About 22% of the fields (31 of 142) were infected. Indoor experiments have shown that this pathogen can survive in alfalfa stems for at least 3 years. Screening tests for bacterial wilt and phytophthora root rot showed that seven cultivars have considerable resistance to these two diseases. The seven cultivars were recommended for registration in Ontario by the Ontario Forage Crop Committee. In vitro experiments showed that a few strains of soil bacteria (fluorescent *Pseudomonads*) can inhibit the growth of PRR, indicating the possibility of their role as biological control agents.

PLANT GENE RESOURCES OF CANADA (PGRC)

The PGRC office is the essential element of a national program whose goals are to obtain, maintain, conserve, and evaluate collections of crop germ plasm, to organize national and international exchanges of plant genetic material, and to provide information and documentation on all of the above.

In 1987, PGRC moved into new quarters with enhanced facilities for storing seed under controlled conditions. PGRC maintains over 82 000 seed samples, including the national base (CN) and active (PGR) collections. Principal world base collections of oats and barley as well as duplicate collections of pearl millet, rapeseed, and mustard are conserved as Canada's contribution to international gene bank activities. The National Apple Repository Network, which involves six Agriculture Canada research stations, preserves almost 200 genetic stocks. Last year, 6559 PGRC accessions were involved in germ plasm exchanges with individuals and institutions in 34 countries.

Information on the Canadian national collections (oats, barley, wheat, tomato, and alfalfa) is stored in computerized data banks. The PGRC newsletter, published semiannually, reports on plant genetic resources activities. It has a mailing list of 752 in Canada and 51 other countries.

PGRC provides a national focus for Canadian activities in plant genetic resources by participating in policy development and by initiating and encouraging projects all across the country.

ELECTRON MICROSCOPY SERVICE

Approximately 100 professional and technical staff of establishments on the Central Experimental Farm and outside agencies made use of the facilities of the Electron Microscopy Unit. The outside agencies included University of Ottawa, Carleton University, National Research Council, Civic Hospital, Canadian Red Cross Society, departments of Energy, Mines and Resources and of Health and Welfare, National Museum of Natural Sciences, Smithfield Experimental Farm, Charlottetown Research Station, and the Prince Edward Island Potato Marketing Board, as well as visitors from Venezuela, Yugoslavia, and the People's Republic of China.

Research done at the unit was reported in over 30 research papers and reports and covered biosystematics of plants, insects, and fungi; detection of plant pathogenic mycoplasmas and viruses in infected tissues; ultrastructure of cheeses and other food products; development of sample preparative techniques and methods for image analysis, including three-dimensional reconstruction; development of computer programs for structural analysis of seed samples; and element analysis of soil, food, and leaf samples by energy-dispersive X-ray detection. These publications are listed in individual reports of research centres and stations.

Users of the instrumentation at the unit were trained in operation of transmission and scanning electron microscopes and all aspects of sample preparation, including critical-point and freeze-drying, metal coating, freeze-fracture and freeze-etch techniques. An oscilloscope was fitted to the ISI-DS130 scanning electron microscope for improved control of brightness and contrast in image recording, and a Deltomatic 65 Kodak print processor was installed for more rapid printing of micrographs.

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Western Region
Région de l'Ouest

W.L. Pelton

R.E. Howarth

Director General *Directeur général*	W.L. Pelton, B.S.A., M.S.A., Ph.D.
Program Specialist *Spécialiste en programmes*	R.E. Howarth, B.S.A., M.Sc., Ph.D.

PREFACE

During 1987, the Pacific and Prairie regions, with headquarters in Vancouver and Regina, respectively, were amalgamated into the Western Region, with offices relocated at Research Branch Headquarters in Ottawa.

The region participates in many joint ventures with provincial governments, universities, producer associations, commodity associations, and agribusiness. Notable examples are the Economic and Regional Development agreements with Manitoba, Saskatchewan, and British Columbia; the Alberta Farming for the Future program; and the Western Grains Research Foundation. In 1987 the region managed a budget of $72.2 million and employed a staff of 1261.

Research is conducted in four program areas: soil and water resources, crop production, livestock production, and food processing and storage. The aim is to solve production problems and to evaluate new opportunities for Canadian farmers in domestic and international markets. The 14 research stations, 4 experimental farms, and 8 substations address production problems in the four western provinces and contribute to solving problems of national scope.

There were many notable achievements during 1987. In soils research, information was gathered on the economic costs of soil loss by wind erosion. Economic assessments and crop productivity data were generated to aid soil conservation through reduced tillage. A study of annual 2,4-D applications to a fallow–wheat–wheat rotation showed no 2,4-D accumulation nor any long-term effects on soil microorganisms or fertility.

New crop cultivars registered in 1987 include Virden barley; Robert oats; Jasper oats; and Orion faba beans. Two early-maturing corn hybrids and a sunflower hybrid were released to the seed trade. Several inbred lines of corn and sunflower were also released. The first commercial harvest of Canadian kiwi fruit was taken in 1987. Recommended seeding and fertilizing practices for semidwarf Canadian Prairie Spring wheats have been developed. The use of row covers provided early maturity of zucchini, cucumbers, cantaloupe, and bell peppers in the Fraser valley. In crop protection research, a bulletin on safe application of herbicides has been in strong demand nationally. Methods were developed for certification of potatoes free of potato spindle tuber viroid and for the detection of virus-like particles associated with little cherry disease. A protocol was developed to kill codling moth eggs, to facilitate the export of fresh Van cherries to Japan. Leaf-gall fly is now established at release sites in Saskatchewan and Nova Scotia and is showing promise for the biological control of perennial sow thistle.

Long-term data on the productivity and economics of beef cow–calf production under short-grass prairie and parkland conditions were published. The 'Alberta' honey bee was registered, with the financial support of Alberta Farming for the Future.

In foods research, shrouding of beef carcasses was found to have minimal influence on carcass grading and appearance; it was recommended to discontinue this standard industry practice. Improved storage conditions were developed for potatoes, peas, buckwheat, and saskatoon berries.

Dr. W.L. Pelton, director general, Prairie Region, was appointed director general, Western Region. Dr. S.C. Thompson, director general, Pacific Region, transferred to the Agricultural Inspection Directorate, Food Production and Inspection Branch, as director general. Dr. J.B. Bole, formerly program specialist, Pacific Region, was appointed director, Morden Research Station. Dr. J.E. Knipfel, former program specialist, Prairie Region, moved to the Swift Current Research Station as a senior research scientist. Dr. R.E. Howarth, program specialist, Prairie Region, was appointed program specialist, Western Region.

R.Z. Rivers, research economist, Pacific Region, transferred to the National Water Research Institute, Environment Canada. D.I. Gourlay, acting chief, Administration, Prairie Region, transferred to Personnel Administration Branch, Regina. J.F. Roberts, chief, Administration, Pacific Region, transferred to the Personnel Administration Branch, Vancouver.

For further information concerning programs, planning, or priorities, write to the research stations directly or to Agriculture Canada, Research Branch, Western Region, Sir John Carling Building, Ottawa, Ont. K1A 0C5; Tel. (613) 995-7084.

W.L. Pelton
Director General

PRÉFACE

En 1987, les Régions du Pacifique et des Prairies, dont les administrations centrales sont à Vancouver et à Regina respectivement, ont été fusionnées à la Région de l'Ouest et leurs bureaux relogés au siège de la Direction générale de la recherche à Ottawa.

La région participe à de nombreux projets mixtes avec les provinces, les universités, les groupes de producteurs, les associations du secteur primaire et l'agrinégoce. À titre d'exemple, on peut citer sa participation aux ententes de développement économique et régional conclues avec le Manitoba, la Saskatchewan et la Colombie-Britannique, et au programme *Farming for the Future* (L'Agriculture de demain) de l'Alberta et à la Fondation des recherches sur le grain de l'Ouest. En 1987, la région gérait un budget de 72,2 millions de dollars et un effectif de 1 261 membres.

Les recherches portent sur quatre domaines, notamment les ressources en sol et en eau, la production végétale, la production animale, la transformation et l'entreposage des aliments. Leur objectif est de trouver des solutions aux problèmes de la production et d'évaluer les nouvelles possibilités qui s'offrent aux agriculteurs canadiens sur les marchés nationaux et internationaux. Les 14 stations de recherches, les 4 fermes expérimentales et les 8 stations satellites s'attachent à résoudre des problèmes qui se posent à la production dans les quatre provinces de l'Ouest et participent à la recherche de solutions aux problèmes de portée nationale.

Plusieurs réalisations remarquables ont eu lieu en 1987. En recherche sur les sols, des données ont été recueillies sur le coût économique de la dégradation des sols par l'érosion éolienne. On a effectué des évaluations économiques et fourni des données sur la productivité végétale pour aider à protéger les sols par le travail minimal du sol. Une étude sur les applications annuelles de 2,4-D dans un assolement jachère–blé–blé n'a révélé aucune accumulation de cette matière active ni d'effets à long terme sur les micro-organismes du sol ou la fertilité.

De nouvelles variétés végétales ont été homologuées en 1987, notamment l'orge Virden, l'avoine Robert, l'avoine Jasper et la féverole Orion. Deux maïs hybrides précoces et un hybride de tournesol ont été lancés dans le commerce des semences. Plusieurs lignées autofécondées de maïs et de tournesol ont également été mises au commerce. On a effectué, en 1987, la première récolte commerciale de kiwis canadiens. On a élaboré pratiques qui sont recommandées pour l'ensemencement et la fertilisation des plantations de blé de printemps semi-nain des prairies canadiennes. Grâce à l'utilisation de paillis sur les rangs, on a pu cultiver des courgettes, des concombres, des cantaloups et des poivrons précoces dans la vallée du Fraser. En matière de recherche sur la protection, un bulletin sur l'application sans risque des herbicides a fait l'objet d'une forte demande nationale. On a mis au point des méthodes de certification de pommes de terre indemnes du viroïde de la filosité des tubercules et des methods de dépistage d'organismes assimilés au virus de la maladie de la petite cerise. On a créé un protocole pour tuer les oeufs de la pyrale de la pomme afin de faciliter l'exportation de cerises fraîches Van vers le Japon. L'insecte gallicole de la feuille, maintenant établi dans les sites de lâchers en Saskatchewan et en Nouvelle-Écosse, donne des résultats prometteurs dans la lutte biologique contre le laiteron des champs.

On a publié des données à long terme sur la productivité et la rentabilité des entreprises de naissage de bovins dans les prairies basses et les prairies-parcs. L'abeille mellifère «Alberta» a été homologuée; cette recherche a reçu une aide financière du programme *Farming for the Future* (L'agriculture de demain) de l'Alberta.

Les travaux de recherche sur les aliments ont montré que la mise des carcasses bovines en chemise de mousseline n'a qu'un effet minime sur le classement et l'apparance; on a donc recommandé de cesser cette pratique courante du secteur. De meilleurs entrepôts ont été créés pour la pomme de terre, les pois, le sarrasin et les baies de petites poires.

Le D^{r} W.L. Pelton, directeur général de la Région des Prairies, a été nommé directeur général de la Région de l'Ouest. Le D^{r} S.C. Thompson, directeur général de la Région du Pacifique, a été muté à la Direction de l'inspection agricole de la Direction générale de la production et de l'inspection des aliments à titre de directeur général. Le D^{r} J.B. Bole, ancien spécialiste en programmes de la Région du Pacifique, a été nommé directeur de la Station de recherches de Morden. Le D^{r} J.E. Knipfel, ancien spécialiste en programmes de la Région des Prairies, a été affecté à la Station de recherches de Swift Current à titre de chercheur principal. Le D^{r} R.E. Howarth, spécialiste en programmes de la Région des Prairies, a été nommé spécialiste en programmes de la Région de l'Ouest.

R.Z. Rivers, économiste chercheur de la Région du Pacifique, a été muté à l'Institut national de recherches sur les eaux d'Environnement Canada. D.I. Gourlay, chef intérimaire de l'administration de la Région des Prairies, a été muté à la Direction générale de l'administration du personnel à Regina. J.F. Roberts, chef de l'administration de la Région du Pacifique, a été muté à la Direction générale de l'administration du personnel à Vancouver.

Pour plus de précisions sur les programmes, la planification ou les priorités, s'adresser directement aux stations de recherches ou à la Direction générale de la recherche du ministère de l'Agriculture du Canada, Région de l'Ouest, immeuble Sir John Carling, Ottawa, Ont., K1A 0C5; Tél. (613) 995-7084.

W.L. Pelton
Directeur général

Research Station, Brandon, Manitoba

PROFESSIONAL STAFF

Administration

E.E. Swierstra, B.S.A., M.S.A., Ph.D.	Director
Vacant	Administrative Officer
S. Ramsay, B.Sc.(Agr.)	Information Officer
R.J. Bomford, B.Sc., M.Sc.	Computer System Manager
E.D. Simundsson,[1] B.A., M.L.S.	Librarian
E.G. Smith, B.S.A., M.Sc., Ph.D.	Economist (ERDA)

Animal Science

G.W. Rahnefeld, B.Sc., M.Sc., Ph.D.	Head of Section; Beef cattle breeding
A.G. Castell, B.Sc., M.Sc., Ph.D.	Swine nutrition
R.L. Cliplef, B.Sc., M.Sc., Ph.D.	Meats physiology
G.W. Dyck, B.S.A., M.Sc., Ph.D.	Swine reproductive physiology
R.R. Grandhi, B.V.Sc., M.Sc., Ph.D.	Swine nutrition
D.L. Grinwich, B.Sc., M.Sc., Ph.D.	Swine reproductive physiology
R.M. McKay, B.Sc., B.S.A., M.Sc., Ph.D.	Swine genetics

Plant and Soil Science

L.D. Bailey, B.S.A., M.Sc., Ph.D.	Head of Section; Soil–plant relationships
P.N.P. Chow, B.Sc., M.Sc., Ph.D.	Herbicides and weed control
D.T. Gehl, B.S.A., M.Sc.	Agronomy (ERDA)
C.A. Grant, B.S.A., M.Sc., Ph.D.	Soil management
W.G. Legge,[2] B.S.A., M.Sc., Ph.D.	Barley genetics
S. Plett,[3] B.S.A., M.Sc., Ph.D.	Corn breeding
J.M. Sadler, B.Sc., M.Sc., Ph.D.	Soil fertility and plant nutrition
R.G. Simons, B.Sc., M.Sc., Ph.D.	Forage agronomy
M.C. Therrien, B.Sc., Ph.D.	Barley breeding

Departure

G.I. Johannson Transferred to Winnipeg Research Station, November 1987	Administrative Officer

VISITING SCIENTIST

A.M. Hinshalwood, B.Sc., Ph.D. Postdoctoral fellow, February 1986 to February 1988	Adjuvant research

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[1] Seconded from Libraries Division, Corporate Management Branch.

[2] Appointed July 1987.

[3] Appointed August 1987.

INTRODUCTION

The Brandon Research Station is one of the five original experimental farms established by the federal government in 1886. The research station occupies 708 ha and leases another 585 ha for research work and feed production.

Much of the research at the station is multidisciplinary and encompasses beef cattle breeding; swine genetics, reproductive physiology, nutrition, and meats physiology; barley and corn breeding; forage crop management; and soil management and crop production. Barley- and corn-breeding programs for the eastern prairies were consolidated at the Brandon Research Station, and Drs. W.G. Legge and S. Plett joined the staff as barley geneticist and corn breeder, respectively.

Mr. G.I. Johannson, administrative officer, transferred to the Winnipeg Research Station.

Highlights of the research programs include the release of the high-yielding, six-row feed barley Virden and the publication of many of the findings in the long-term beef-breeding program designed to determine the contribution that Continental (exotic) breeds of cattle can make to the Canadian beef industry.

The short reports that follow give results of recent research as well as an indication of the types of studies that are in progress. Further information may be obtained from the publications listed at the end of these reports or by direct contact with individual scientists. Correspondence or requests for reprints should be addressed to the Research Station, Research Branch, Agriculture Canada, Box 610, Brandon, Man. R7A 5Z7; Tel. (204) 728-7234.

E.E. Swierstra
Director

ANIMAL SCIENCE

Beef cattle

Beef cattle reproduction in relation to environment. The lifetime reproductive performance of beef cows was evaluated for two genetically similar populations over a 10-year period at two contrasting environments (Brandon, Man., and Manyberries, Alta.). The data comprised records for 8160 cow-years. The breeding herds were maintained for 6 years in accordance with management practices conventional in each location, with winter management changed to drylot feeding for the final 4 years. Location differences in cow performance favored the herd maintained under semi-intensive parkland management at Brandon. Conception rates were higher, calf mortality was lower, and preweaning calf gains were greater than those recorded for the contemporary herd maintained under extensive rangeland management at Manyberries. These differences in performance gave the Brandon herd a 16% advantage in weight of calf weaned per mating opportunity. In the fall of 1977 (the 7th year of the study), cows at Manyberries were 15% lighter and had 60% less fat than their Brandon contemporaries. These differences increased to 19 and 80%, respectively, during the first winter in feedlot confinement, even though the daily energy allowance was 20% above 1976 National Research Council of Canada–National Academy of Sciences (NRCC–NAS) requirements. Conception rates at Manyberries were seriously affected by mortality of both cows and calves and were inversely related to cow fat at calving. An increase (42% above NRCC–NAS levels) in feed input at Manyberries the following winter, coupled with the opportunity for tissue restoration provided by a barren year, reversed the downward trends in weight and fat. Weight equivalence of the two herds was achieved by 1980. During the last 4 years, milk yields from pastured cows were generally higher for the Brandon herd. However, calf growth from birth to 2 months of age was greater at Manyberries.

Genotype × environment interactions for postweaning growth performance of backcross bulls. The effects of pretest periods and genotype × environment (GE) interactions were evaluated for 40 postweaning performance traits in 137 reciprocal backcross bulls produced under two contrasting environments (Brandon, Man., and Manyberries, Alta.).

Differences in weaning weight and average daily gain during the pretest periods – associated with the fixed effects of station of origin, breed cross, and station of origin × test interactions – were not significant. The pretest periods were defined as preweaning, weaning to on-test, and birth to on-test. Station-of-test effects were significant ($P = 0.0001$) for average daily gains from weaning to on-test and from birth to on-test. None of the GE interactions with station of origin were significant ($P > 0.10$) for the postweaning growth traits, and probabilities exceeded 0.20 for all but three traits. The GE interactions with station of test were not significant ($P > 0.20$) for all but eight traits. All of these exceptions involved the cumulative average daily gain in the eight periods, which excluded the first 14 days of test. The GE interaction for average daily gain over 140 days of test was not significant.

Genotype × environment interactions for carcass traits of backcross bulls. The effects of station of origin, station of test, and genotype × environment interactions were evaluated for carcass traits of 121 backcross bulls. The results suggested that (with respect to these characteristics) station of origin, station of test, and genotype × environment interactions would not be of any major importance in the planning of breeding programs or performance tests and in the transfer of beef cattle from the environment where they were raised and developed to another location.

Efficiency of feed utilization by three-breed cross steers. Feed efficiency, defined as feed-to-gain or feed-to-weight ratio, was computed on both a live-animal basis and an edible-product basis for 1046 crossbred steers reared between 1973 and 1978 at Brandon, Man. The progeny were out of 10 specific F_1 crosses of dams mated to Charolais (C), Simmental (S), Limousin (L), and Chianina bulls. Dam crosses included the Hereford × Angus (HA) and nine others produced by mating C, S, and L sires with H, A, and Shorthorn cows. Results indicated that feed efficiency should be expressed on an edible-product basis rather than on a live-animal basis.

Economics of calf production with foreign cattle breed crosses in the short-grass prairies. An economic analysis of cow–calf production indicated the importance of weaning weight, weaning percentage, calving difficulty, and daily energy requirements of the dam in determining profits. Returns were calculated for 31 three-breed crosses from a project that produced 2079 live births and weaned 1866 calves over a 6-year period at the Onefour Substation near Manyberries, Alta. Ten breed cross dams of Hereford–Angus, Charolais–Hereford, Charolais–Angus, Charolais–Shorthorn, Simmental–Hereford, Simmental–Angus, Simmental–Shorthorn, Limousin–Hereford, Limousin–Angus, and Limousin–Shorthorn were bred to Charolais, Simmental, Limousin, and Chianina sires with no backcrossing to produce three-breed cross calves.

Simmental–Angus and Charolais–Shorthorn were the most profitable breed of cross dams. Limousin-cross dams were the least profitable, up to $140 per dam less than the most profitable crosses. Hereford–Angus dams were, at best, $20 per dam less than the most profitable crosses. Charolais and Limousin sires were more profitable than Simmental and Chianina.

Feeder calf price differences by breed cross: A bio-economic determination. An economic analysis of finishing 31 three-breed crosses of beef calves indicated several reasons why calves of different breeds but similar weight would receive different prices. Price differences among the breed crosses of finished calves occurred because of differences in carcass grade and yield, rate of gain on feed, and feed efficiency. The relative prices that could have been paid for feeder steers produced by mating Charolais (C), Simmental (S), Limousin (L), and Chianina (Chi) sires to Hereford (H)–Angus (A) dam crosses and for nine other crosses produced by mating C, S, and L sires to HA and Shorthorn (N) cows were determined for calves of equal weights. Three methods of pricing feeder steers were used to determine the amount that could be paid for a finished calf. These pricing methods were based on live weight, dressed weight, and lean weight.

On a liveweight basis, feed efficiency was the primary determinant of relative feeder prices. Finished calves from C, S, and Chi terminal sires were priced higher than L-sired calves. By breed cross of dam, feeder steers from HA, SH, SA, and LH cows were priced lower than those from CH, CN, SN, and LN cows. On a dressed-weight basis, feed efficiency and dressing percentage were the primary determinants of relative feeder prices. Finished calves from S and L terminal sires were priced the lowest; Chi-sired calves, the highest. By breed cross of dam, feeder steers from HA and LH cows received the lowest price and those from CH, CN, SN, and LN cows, the highest. Pricing on a lean-weight basis took into account lean yield as well as feed efficiency and dressing percentage. Finished calves from S sires were priced the lowest and those from Chi sires, the highest. By breed cross of dam, feeder steers from HA cows received the lowest price; those from CH, CA, CN, SN, LA, and LN cows, the highest.

Swine

Growth and fat deposition in swine. Age and probed back-fat thickness are traits currently adjusted to 90 kg liveweight, with factors provided by the Canadian record of performance program for swine. These adjustment factors assume that growth rate and back-fat deposition are uniform across breeds, sexes, and farrowing seasons. To test this assumption, the relationships of liveweight with age and probed back-fat thickness were examined on 1775 market pigs. These animals represented the Lacombe and Yorkshire breeds, boars and gilts, and spring and fall farrowings. In light of the effects of breed, sex, and farrowing season found in this study, further research is required on adjustments made to specific liveweights for age and probed back-fat thickness using animals that are representative of those found currently in the Canadian swine population.

Effects of linecross and delayed castration on growth and carcass traits in swine. A total of 212 boars and barrows were examined to determine the effects of linecross and castration treatment on live animal growth and carcass traits. The linecrosses were derived from mating Landrace boars to Yorkshire control, Yorkshire select, and Hampshire select first-litter sows. The treatments were no castration, early castration (average age of 12 days), and late castration (average age of 100 days). Results showed that delaying castration did not adversely affect carcass merit, but any advantage in live animal growth was dependent upon the linecross.

Estrogen injections and boar exposure to stimulate puberty in gilts. At 160 days of age, Lacombe gilts were relocated from a confinement grower facility to outside pens, given estrogen injections or no treatment, and exposed to mature boars for 30 min a day or had no contact. Exposure to mature boars had no effect on the number of gilts in estrus by 200 days of age. In contrast, a higher proportion of estrogen-treated gilts than control gilts were in estrus by 200 days of age (87 versus 59%). Estrogen-treated gilts averaged 4.5 days to their first detected estrus, and control gilts averaged 16.9 days to estrus. Estrogen-treated gilts also had a lower ovulation rate (6.2 versus 12.8), more gilts in estrus without ovulating (33 versus 15%), and more gilts with cystic follicles on the ovaries (12 versus 1%). Results demonstrated that estrogen injections induced behavioral estrus and probably stimulated the secretion of luteinizing hormone, causing only the follicles that were mature at the time of treatment to ovulate. While estrogen injections would stimulate estrus at an earlier age than other procedures, adverse effects on the ovary indicated why it would not be desirable to breed gilts at this time.

Reproductive performance in gilts fed high-energy and lysine-supplemented diets. Reproductive performance was evaluated in 356 Landrace × Yorkshire crossbred gilts to determine the effects of increasing the feed allowance (flushing) and feeding supplemental fat and lysine from puberty to breeding or from puberty through early gestation. The treatment groups did not differ ($P > 0.05$) in ovulation rate and fetal development. Flushing and feeding supplemental fat from puberty to breeding reduced ($P < 0.05$) embryo survival in one of four experiments. Feeding supplemental fat from puberty through early gestation also reduced ($P < 0.05$) embryo survival in one experiment. Overall results indicated that the low heat increment property of fat and superior amino acid balance of lysine diets were unable to improve the maternal uterine environment and increase potential litter size in gilts.

Use of lentils in pig diets. From 25 to 90 kg liveweight female pigs were self-fed 16% protein diets containing 0, 10, 20, 30, or 40% cull lentils (cultivar Eston, 27% protein). Partial or complete replacement of the dietary soybean meal by lentils did not affect ($P > 0.05$) live performance or routine carcass measurements. However, assessments of meat quality favored pigs fed diets containing not more than 20% lentils. Results complemented those from a previous study and confirmed the potential of cull lentils when used as 10–20% of barley diets for growing pigs.

Raw soybeans in pig diets. From 30 to 95 kg liveweight, young boars were self-fed 16% protein diets containing 0, 4.5, 9.0, 13.5, 18.0, or 22.5% soybeans (cultivar Maple Amber, 17% oil and 36% protein). Significant ($P < 0.01$) responses to the higher levels of soybeans included reductions in growth rate, efficiency of feed conversion, side as a percentage of carcass weight, and lean areas of the loin and ham face. Back fat also became more unsaturated. Sensory evaluation revealed a higher incidence of off-flavor in roasts from pigs fed in excess of 9% soybeans in the diet. The use of raw soybeans as an ingredient appeared to have little potential at levels over 5% of the diet for growing pigs.

Optimal protein levels and marketing weights for feeder hogs. Profits from finishing hogs on either grower diet or finisher diet versus a combination of the two (using grower diet initially and switching to finisher diet at higher weights) were determined for various economic conditions. The combined use of a 16% crude protein (CP) grower diet and a 14% CP finisher diet proved to be the most profitable feeding program under current conditions in the prairies of western Canada. The hog weight at which diets were switched was 45 kg. The cost of grower and finisher diets was the primary determinant of the feeding program. When the grower diet was priced less than 20% higher than the finisher diet, using the grower diet through to marketing was the most profitable feeding program. When the grower diet was priced 40% higher than the finisher diet, the most profitable feeding program was the finisher diet. Results indicated that as the cost of the grower diet increased relative to that of the finisher diet, the weight at which hogs should be placed on finisher diet would decrease. The daily gain of feeder hogs would be less when fed the finisher diet, but profits would increase because of lower feed costs. Differences in growth existed between gilts and barrows, but the diets and weights at which diets should be switched were similar.

PLANT AND SOIL SCIENCE

Cereals

Barley breeding and genetics. A new six-row feed barley was released in May 1987 and registered under the name of Virden. This cultivar combines very high yield potential with strong straw, resistance to common root rot, *Cochliobolus sativus* (Ito & Kurib.) Drechs ex Dast., and large kernel size. Virden outyields Heartland by 6% in western Canada and Bedford by 7% in Manitoba and has stronger straw than both cultivars. Its area of adaptation is the Black soil zone of western Canada, with the exception of areas with a high risk of frost, since Virden matures 4 days later than Bonanza and is classified as a late-maturing cultivar.

The new form of resistance to true loose smut, *Ustilago nuda* (Jens.) Rostr., derived from the barley landrace CI 9973, exhibits a more complex pattern of inheritance than previously reported. This resistance is dominant and may be oligogenetic. The trait is not associated with chromosomes 4 or 5 in barley. However, there is evidence to suggest an association with chromosome 2 and linkage to the two-rowed (V) character in barley. This form of resistance confers immunity to prevalent races of true loose smut in western Canada and has been transferred to a number of barley synthetics with CI 9973 as the donor parent.

The herbicide glyphosate was used as an effective tool in eliminating late-maturing genotypes from the F_3 generation of a barley-breeding program. Time of spraying and environmental conditions were the two main factors that determined the effectiveness of treatment. Under conditions of adequate moisture and a 6-day range of maturity for F_3 progeny, the average maturity for a population of 1000 individuals was reduced by 3 days. Under drought conditions, however, no reduction in maturity was evident. There was also a high level of variation for average maturity, indicating that this method was not precise and should be used only as a coarse screening technique for relatively large populations.

Forages

Steroids in forage plants. Four mammalian steroids were found to be widespread in plants. Radioimmunoassay was used to investigate the prevalence of androstenone (boar taint), androgen, estrogen, and progesterone in forages and other plants. Androstenone is known only from pigs and humans, but the others are important in the regulation of mammalian reproduction. A total of 129 plant species from over 50 families were sampled. All four steroids were widespread, with androstenone and progesterone found in more than 80% of the species, androgen in 70%, and estrogen in 50%. Androstenone was detected in the leaves of birdsfoot trefoil and eight forage grasses tested but not in alfalfa or sweetclover. All seed samples contained androgen, but none contained androstenone. Androgen was more abundant in male tissue than in female tissue. Progesterone and estrogen, when present, were at higher levels in female tissue. The function of these steroids in plants is not known. However, they may be involved in growth regulation, sex determination, or protection against insects.

Soil management and crop production

Fertility requirements of grain sorghum. A 3-year field study examined the fertility requirements of grain sorghum on Manitoba soils deficient in phosphorus. The greatest yield increases and yield increases per unit of applied phosphorus (banded at seeding) occurred when the fertilizer was placed either 2.5 or 5 cm below and to the side of the seed. On fine-textured soils, placing the phosphorus band 2.5 cm directly below the seed produced yields that were 5–10% lower compared with sidebanding. Placing phosphate (as monoammonium phosphate), at a rate of as little as 12 kg/ha, with the seed reduced crop emergence by 25–68% and grain yields by 7–25% compared with sidebanding.

Fertility requirements of spring wheat. A 3-year field study at three sites in Manitoba examined the yields and nitrogen fertilizer responses of semidwarf spring wheat cultivars versus conventional spring wheat cultivars. The maximum yields of Katepwa (a conventional Canada western red spring cultivar) and HY 320 (a semidwarf Canada prairie spring cultivar) were obtained with similar levels of applied nitrogen. At a specific level of nitrogen fertility, there was a strict negative relationship between grain yield and grain protein content for a cultivar. These results indicated that Manitoba's existing nitrogen fertilizer recommendations for spring wheat from the Provincial Soil Testing Laboratory would apply equally to conventional and to semidwarf cultivars.

Soybean inoculants for the Canadian prairies. A series of experiments were conducted to identify strains of *Bradyrhizobium japonicum* that are effective nodulators with early-maturing Canadian soybean cultivars and that can overwinter in prairie soils. *Bradyrhizobium japonicum* strains 61A148, 61A155, 61A194, and 61A196 were similar in effectiveness but superior to strains 61A101c, 61A118b, and 61A124a and a commercial mixture of four strains (61A101c, 61A118b, 61A124a, and 61A148) in earliness of nodule formation as well as in number and weight of nodules per plant. The superior strains also promoted greater root growth, top growth, and nitrogen accumulation in the soybean cultivars tested (Maple Amber and Maple Presto). Maple Amber showed greater potential for symbiotic nitrogen fixation.

Yield and protein content of soybeans increased when the crop was inoculated with the appropriate strain of *B. japonicum*, whether or not the soil had previously grown inoculated soybeans. This increase in yield was greater when single strains of inoculant were used compared with a multistrain commercial mixture. Under field conditions, all *B. japonicum* strains did not survive or lost their nodulating activity over the winter.

Weed control. Five grasskillers (AC 222 293, FOE 3440A, HOE 33171, PP 604, and flamprop-L) showed good control of wild oats, but AC 222 293 and PP 604 were not effective against green foxtail. In tests with Katepwa wheat, crop tolerance of all herbicides was excellent.

BAS 517 and RE 45601 consistently performed well against grassy weeds in oilseed crops. Their herbicidal activity was enhanced by the addition of appropriate surfactants. Mixtures of these chemicals with MCPA amine, bromoxynil, and bromoxynil–MCPA improved control of grassy and broadleaved weeds in flax, as evidenced by increases in crop yield.

In a small-plot study, the application of clopyralid alone or with diclofop-methyl or sethoxydim reduced number of flowers and subsequent yield of canola.

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Research Station, Morden, Manitoba

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W. Dedio, B.S.A., M.Sc., Ph.D.	Breeding of sunflowers
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Departures

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D.K. McBeath, B.S.A., M.Sc., Ph.D. Transferred to Fredericton Research Station as director July 1987	Director

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T.K. Bhati Dryland Research Project	Agronomist
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[1] Appointed July 1987.

[2] On transfer of work to London Research Centre, September 1987 to September 1988.

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[5] Appointed December 1987.

INTRODUCTION

The programs at the Morden Research Station are directed toward the development of new cultivars and the improvement of production and preservation methods for buckwheat, field peas, new crops, flax, sunflowers, potatoes, vegetables, and herbaceous and woody ornamentals. This report summarizes some of the results obtained from research conducted during 1987.

An early high-yielding oilseed sunflower hybrid and 15 early or disease-resistant sunflower lines were released. Two superior early corn hybrids and 19 inbred lines with the combination of high yield and early maturity were released in accordance with the new corn hybrid–inbred release policy. An ivory-pink rose selection is being propagated for introduction as a new cultivar. Field pea introductions were identified as having a high fiber content. Data was provided to support the registration of six new herbicide uses for field or special crops. Agronomic studies defined situations where canola and barley residues adversely affect yield of flax and determined appropriate row spacing for sunflowers. Food research has led to the development of improved storage management practices for potatoes and peas, defined the effect of buckwheat storage on quality, described methods of stabilizing pigment color in saskatoon berries and other food products, and provided new data for the development of *Monarda* as a unique source of geraniol.

Further information on any of these research activities and reprints of publications listed in this report may be obtained from the Research Station, Research Branch, Agriculture Canada, P.O. Box 3001, Morden, Man. R0G 1J0; Tel. (204) 822-4471.

J.B. Bole
Director

FIELD CROPS

Buckwheat

Weed control. Desmedipham applied when buckwheat was 5 cm in height controlled wild mustard, redroot pigweed, and lamb's-quarters, with acceptable crop tolerance. Excellent buckwheat tolerance to new graminicides was confirmed.

Field corn

Breeding. Two corn hybrids, Morden 8522 and Morden 8524, were released. Morden 8522 is an extremely early hybrid requiring 2100 corn heat units to mature. It had a yield moisture index of 12.0 as compared with 11.3 for the mean of the checks. Morden 8524 is an early hybrid requiring 2150 corn heat units to mature. Its yield was 3.83 t/ha as compared with 3.80 for the mean of the checks and had a yield moisture index of 11.5. These hybrids will help expand the corn production area northward. Nineteen inbred lines, chosen for earliness and good combining ability, were released under the corn hybrid–inbred release policy.

Weed control. R-25788, a safening agent, improved the performance of SC-5676 on annual weeds. When cyanazine was added to SC-5676 plus R-25788, most annual broad-leaved and grassy weeds were controlled.

Field peas

Breeding. Pedigreed seed of Titan, a new Century-type high-yielding cultivar, was released through the SeCan Association to 86 growers in Manitoba and Saskatchewan.

MP 954, a high-yielding yellow-seeded selection that is larger in seed size and earlier in maturity than Century, will be considered for registration next year.

A method has been developed to identify field pea cultivars by electrophoretic analysis of cotyledon proteins. This method would be useful in cultivar identification, in instances where identity cannot be determined by morphological traits.

Screening of field pea introductions from world collection for seed coat content (edible fiber) revealed that seven accessions had a seed coat content of 11%, which is 2–3% higher than the check cultivars. These accessions will be used in the breeding program to develop high-fiber cultivars.

Weed control. Cyanazine or EL-107, applied preplant and incorporated into the soil, controlled wild mustard with satisfactory crop tolerance. Both herbicides appeared to be suitable adjuncts to trifluralin for broad-spectrum weed control.

Dry field beans

Weed control. Ethalfluralin applied preplant and incorporated into the soil controlled wild oats, green foxtail, volunteer barley, and several broad-leaved weeds. Quizalofop applied postemergence was equally effective on annual grasses and volunteer cereals.

New crops

Weed control. Desmedipham, applied when safflower was 3 cm in height, controlled redroot pigweed, lamb's-quarters, and wild mustard with acceptable crop tolerance.

OILSEED CROPS

Flax

Breeding. In a growth cabinet study, cultivars differed in the duration of the growth period before and after flowering. Culbert, Linott, Marine, NorLin, Raja, and Redwing had the shortest period to flowering, whereas Dufferin, McGregor, Noralta, and NorMan had the shortest period from flowering to maturity. Since cultivars differ in the duration of these growth periods, flowering time alone is not a reliable indicator of the time a cultivar requires to mature.

Cultivars also differed in the production of basal branching. Dufferin, McGregor, Noralta, and NorMan produced a significantly higher number of branches than Linott, Marine, NorLin, or Raja.

Management. With no tillage before seeding, flax yields were comparable on canola and barley stubble. However, with conventional tillage before seeding, flax yields were generally lower on canola than on barley, whereas barley yields were higher on canola than on barley stubble. Spring volunteer canola seedlings often reduced flax yields, but fall seedlings had no marked effect.

Weed control. Tank mixes of sethoxydim plus bromoxynil–MCPA (4-chloro-2-methylphenoxyacetic acid) mixtures, caused less injury to flax when sprayed in the afternoon or evening than when sprayed in the morning. Flax injury was most severe when sprayed between 5:00 and 9:00 a.m. Directing spray nozzles 45° forward increased the efficiency of sethoxydim by about 45%. Sethoxydim sprayed 7 days after flax emergence was more effective on wild oats than were later applications, but stage of treatment had little effect on the control of green foxtail or volunteer wheat.

Sunflowers

Breeding. An early sunflower oilseed hybrid, MRS 37, has been recommended for registration. It matures 7–9 days earlier but yields 3% less than currently grown hybrids.

Fifteen sunflower lines (14 oilseed and 1 nonoilseed) were released as germ plasm for earliness with good agronomic characters or resistance to rust, verticillium wilt, or downy mildew.

Poor correlations between oil content of parental lines and hybrids are often obtained when they are based on oil content of single, bagged heads, single rows, or too few replicates. The range of correlation coefficients was –0.365 to 0.440 in three-replicate tests in 1985, but improved to 0.744 and 0.902 in two six-replicate tests in 1986. Bagging the heads resulted in lower correlation coefficients, as seed set was affected by self-compatibility, which in turn affected oil content.

Management. Early and late oilseed sunflower hybrids were grown at 45- and 90-cm row spacings in the 1984–1986 seasons. In the 45-cm rows compared with the 90-cm rows, plant height was reduced approximately 6 cm, oil content was increased approximately 0.5%, and achene yields were increased 8% for early hybrids and 3% for late hybrids.

Weed control. AC 222 293 was effective on wild mustard when applied to sunflowers at the two- to three-leaf stage, but control declined progressively when spraying was delayed. Acceptable control of wild mustard, redroot pigweed and lamb's-quarters was also obtained with RE-40885 applied preplant and incorporated into the soil. Ethalfluralin plus EL-107 applied preplant and incorporated into the soil continued to be an outstanding treatment for broad-spectrum weed control.

HORTICULTURAL CROPS

Ornamentals

Breeding and evaluation. A weigela breeding program was successfully transferred to Morden from the Plant Research Centre in Ottawa. In total, 30 selections–cultivars were received as rooted cuttings and were planted in the field.

A taxonomic study of the shrubby cinquefoil was completed. Both numerical and experimental approaches were utilized. Interpretation of cluster and nonmetric multidimensional scaling statistical analyses suggested that all taxa (127) were similar and were variants of a common central theme. Eight geographic representatives (Northern Hemisphere) were successfully intercrossed. Heteroploid matings were noted by reduced success rates. Backcrosses to existing F_1 hybrids were successful. On the basis of this study, *Potentilla fruticosa* should be used as the species name for the shrubby cinquefoil complex.

Superior plants from the shrubby cinquefoil breeding program were selected. In total, 130 plants were identified with improved flower color (containing anthocyanin), plant form, or double flowers.

Detailed observations on flowering and fruiting in the genus *Prunus* were conducted. Flowering was first observed in apricot cultivars and last in black cherry. The largest fruit was obtained from the plum cultivar Royal (53.0 g) whereas the smallest was from Amur cherry (0.1 g). Plants were grouped by flowering dates; however, no relationship between days from flowering to fruit ripening or fruit size was noted.

Detailed evaluation of plant accessions in the arboretum centred on *Cornus* (21), *Spiraea* (32), and *Philadelphus* (53). Flowering observations were recorded for each taxon.

During 1987, 700 accessions were obtained from a diversity of sources for testing under prairie growing conditions. These included various seeds (388), plants (222), cuttings (38), and scion wood for budding or grafting (52).

A report of the prairie regional trials for woody ornamentals (1958–1987) was completed, summarizing performance of over 1200 accessions on the basis of hardiness and adaptability. These have been tested at up to nine locations across the prairies and northwestern Ontario.

Four advanced selections have been developed in the rose-breeding program. An ivory-pink selection is being propagated for introduction as a new cultivar. A scarlet-red rose is under consideration for release to the nursery trade. Two red-flowered selections have been advanced to regional tests. Nine seedlings, chosen for resistance to blackspot and for their white or yellow flower color, will be entered into an advanced evaluation trial.

Six *Hosta* were identified to the trade as valuable landscape plants, while *Penstemon* Skyline Mixed, a commercial seedline, was not suitable as an ornamental plant. Four species and two cultivars of *Hosta* have survived well since 1982: *H. cathayana*, *H. crispula*, *H. nakaiana*, *H. plantaginea*, *H. undulata* 'Erromena', and the *Hosta* cultivar Honeybells. Although seedlings of *Penstemon* Skyline Mixed flowered in the first season of growth, none survived through the winter and therefore cannot be recommended for the prairies.

Intersectional hybrids of lily (*Lilium*) were successfully propagated from bulb scales using tissue culture techniques, with Murashige and Skoog lily multiplication media. This method of propagation will decrease the time required to produce plants for regional testing.

Potatoes

Cultivar evaluation. NDA 8694-3, a product of the breeding program at North Dakota State University, selected at Aberdeen, Idaho, has completed 3 years of testing in the prairie replicated trials. It was recommended for commercial evaluation by the Breeding and Selection Committee of the Prairie Potato Council. A 1st-year interim registration for NDA 8694-3 was requested by the Prairie Potato Council in 1987. It has tubers which are oblong, with shallow eyes and a smooth, russet skin. Tuber sizing of NDA 8694-3 is earlier than Russet Burbank, and tuber yields are generally greater until mid to late August. Processing quality from the field is acceptable, but generally with a slightly lower specific gravity and slightly darker fry colors than Russet Burbank. NDA 8694-3 shows some tolerance for drought and appears best adapted to production under dryland conditions in Manitoba.

Management. Three commercial growth regulators Cerone (Union Carbide), Cyccocel (BASF), and Terpal C (50% Cerone : 50% Cyccocel, v/v) were evaluated for their effect on tuber yield, tuber size distribution, and processing quality of Russet Burbank. Application of the growth regulators resulted in an increase in the number of tubers set but with a decreased mean weight of individual tubers. The incidence of hollow heart tended to be reduced with the Cerone and Terpal C applications, whereas the Cyccocel treatment resulted in a slightly increased incidence of hollow heart compared with the untreated check.

Utilization and quality

Cauliflower. Yield, Hunter color functions and sensory ratings of color, texture, and flavor for six cultivars of cauliflower were determined. Yield and objective color measurements were found to be influenced by cultivar and growing season. Sensory evaluation, however, revealed that all cultivars yielded frozen products essentially identical to those currently available in the marketplace. To allow for an extended processing season, the earliest cultivar (Snow Crown), the mid-season cultivar (Andes), and the late-season cultivar (White Fox), appear most suitable for the prairie region. Furthermore, the data in this study suggest Hunter lab *L* values are an adequate parameter for assessment of curd color of cauliflower cultivars.

Monarda. The influence of the distillation method, condition of plant material, cultivar, and growing season on yield and quality of geraniol-rich *Monarda fistulosa* L. var. *menthaefolia* was investigated. Based on gas chromatographic analyses, the quality of the oil was not affected by the production and processing variables investigated. The major component of the oil was geraniol, followed by linalol, neral, and γ-terpinene. The yield of oil, however, was influenced by method of distillation and condition of plant material. Oil yield was higher from fresh and wilted plants than from baled material, higher from circulatory glass still than from pilot mint still and hydrodiffusion apparatus, and higher from plants of Morden No. 3 than from plants of Morden No. 82-1T *Monarda*.

Buckwheat. The influence of cultivar and storage regime on lipid content and fatty acid composition of buckwheat seed was determined. Dehulled seeds of the three most important North American cultivars of buckwheat, Mancan, Tokyo, and Manor, were analyzed for content of total, free, and neutral lipids, glycolipids, and phospholipids. Also, each class of lipid was analyzed for fatty acid composition. The samples contained 2.6–3.2% total lipids, of which 81–85% were neutral lipids, 8–11% phospholipids, and 3–5% glycolipids. Free lipids, extracted in petroleum ether, ranged from 2.1 to 2.6%. Most fatty acids of all cultivars and of all classes of lipids were palmitic (16:0), oleic (18:1), and linoleic (18:2) acid. Average values of these three fatty acids in the total lipids of all buckwheat samples examined averaged 14.0, 36.3, and 37.0%, respectively. The corresponding values for the free lipids were 14.8, 36.5, and 35.5% and those for phospholipids were 9.1, 44.3, and 41.7%, respectively. Total lipid content was positively correlated with free lipids, neutral lipids, and glycolipids, and there was a negative correlation between oleic and linoleic acid content of all lipid classes. There was, however, no statistical difference between recently harvested and year-old buckwheat in the content of free lipids, neutral lipids, glycolipids, and phospholipids and in the fatty acid composition of total and free lipids. The research is an important step in developing practices that will allow producers to store buckwheat and control its supply on the export market.

Peas. The tangential abrasive dehulling device (TADD) was modified and used to evaluate the effects of seed moisture content (6–20%) and temperature (-40 to 40°C) on seed coat breakage of Trapper and Tara field peas. Seed coat breakage of peas at 24°C and 14–15% seed moisture content (approximating harvest conditions) was comparable to seed coat breakage of commercially harvested farmers' samples. Seed coat breakage was affected mostly by seed moisture content, followed by temperature and cultivar. Seed coat breakage increased linearly (r = -0.92 to -0.99), with decreasing moisture content for both cultivars. Generally, breakage increased with decrease in seed temperature and was particularly extensive at -40°C. The effect of low temperature (-40°C) on seed coat durability was completely reversible. To avoid excessive seed coat breakage, it is recommended that peas not be handled at a moisture content of less than 14% or at temperatures below -25°C and that they be handled with care at temperatures between -10 and -25°C.

Potatoes. Twenty commercial storage bins, each containing 2000–3000 t of potatoes, were monitored for 2 years for carbon dioxide content of the storage atmosphere and for reducing sugars, sucrose, specific gravity, and chip color of the tubers. Concentration of CO_2 in the bins ranged from 0.055 to 3.5%. Values higher than 1% were found in about 50% of the bins tested. The high CO_2 levels occurred primarily during application of the sprout inhibitor CIPC. Reducing sugars and sucrose content ranged from 0.06 to 0.81% and from 0.43 to 2.35 mg/g of fresh tuber, respectively. Increases in reducing sugars and sucrose, and darkening of the chips and French fries made from the tubers, generally occurred immediately after a rise in CO_2 concentration. For most bins, the detrimental effect of high levels of CO_2 on the color of the fried products was temporary.

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Research Station, Winnipeg, Manitoba

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G.I. Johannson[1]	Administrative Officer

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E.R. Kerber, B.S.A., M.Sc., Ph.D.	Wheat cytogenetics
M.I.P. Kovacs, B.Sc., M.Sc., Ph.D.	Cereal chemistry
D. Leisle, B.S.A., M.Sc., Ph.D.	Durum wheat breeding
O.M. Lukow,[6] B.Sc., M.Sc., Ph.D.	Cereal chemistry
D.R. Metcalfe, B.S.A., M.Sc., Ph.D.	Barley breeding and genetics
R.I.H. McKenzie, B.S.A., M.Sc., Ph.D.	Triple-medium wheat breeding
J.S. Noll, B.Sc., Ph.D.	Cereal chemistry and physiology

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J. Chong, B.Sc., M.Sc., Ph.D.	Oat crown rust
S.M. Haber, B.Sc., M.Sc., Ph.D.	Cereal viruses and biotechnology
D.E. Harder, B.Sc., M.Sc., Ph.D.	Oat stem rust
N.K. Howes, B.Sc., Ph.D.	Molecular biology and biotechnology
W.K. Kim, B.Sc., M.Sc., Ph.D.	Molecular biology and biotechnology
J.A. Kolmer,[8] B.S., M.S., Ph.D.	Wheat leaf rust
J.J. Nielsen, Dr.Sc.Agr.	Smuts
R. Rohringer, Dr.Sc.Agr.	Molecular biology and biotechnology
A. Tekauz, B.Sc., M.Sc., Ph.D.	Leaf diseases
P.L. Thomas, B.S.A., M.Sc., Ph.D.	Microbial genetics, smuts

Stored Products

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D. Abramson, B.Sc., M.Sc., Ph.D.	Mycotoxicology
P.S. Barker, I.A., M.Sc., Ph.D.	Biology and control of stored grain mites
R.N. Sinha, B.Sc., Ph.D.	Ecology of granary pests
N.D.G. White, B.Sc.Agr., M.Sc., Ph.D.	Biology and control of stored product insects

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B.E. Galka,[9] B.Sc., M.Sc.	Economic entomology
G.H. Gerber, B.S.A., Ph.D.	Histology, physiology, and behavior
R.J. Lamb, B.Sc., M.Sc., Ph.D.	Systems biology
O.N. Morris, B.Sc., M.Sc., Ph.D.	Insect pathology
P. Pachagounder,[10] B.Sc.Agr., M.Sc.Agr., Ph.D.	Insect–plant relationships

Departures

T. Czyczko Resigned 22 May 1987	Systems Manager
M.D. Hamilton Retired 13 November 1987	Administrative Officer
S.R. Loschiavo, B.Sc., M.Sc., Ph.D. Retired 30 October 1987	Stored grain insect biology
W. Romanow, B.S.A., M.Sc. Retired 30 October 1987	Insecticide evaluation and management
G.H. Wylie, B.A., Ph.D. Retired 30 January 1987	Insect parasitology

VISITING SCIENTISTS

J. Sock, M.Sc., Dr.Sc.Agr. Postdoctorate fellow (Deutsche Forschungsgemeinschaft) September 1986–September 1987	Molecular biology of cereal rusts
K. Ahmed, Ph.D. International Development Research Centre (IDRC) training visit (Pakistan) March–July 1987	Microbial control of insects
H. Kawamoto, Ph.D. Natural Sciences and Engineering Research Council (NSERC) research associate, seconded from the Department of Agricultural Engineering, University of Manitoba March 1987–March 1989	Population ecology
H. Zhang Visiting scientist, Northwest Plateau Institute of Biology, Academia, Sinica, People's Republic of China July 1987–July 1988	Wheat breeding and quality

Graduate students

R. Butts, B.Sc., M.Sc.	Entomology
S. Fox, B.Sc.A.	Oat breeding
L. Kawchuk, B.Sc.	Bunt of wheat
W. Legge, B.S.A., M.Sc.	Durum wheat research
Luo Ma, B.Sc., M.Sc.	Physiology and biochemistry of insects
L. Maksymetz, B.S.A.	Smut genetics
D. Tuma, M.Sc.	Food mycology
T. Warkentin, B.S.A.	Oat breeding

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[1] Appointed 30 November 1987.

[2] Appointed 31 August 1987.

[3] Seconded from Libraries Division, Corporate Management Branch.

[4] Appointed 1 October 1987 as head of Cereal Breeding Section.

[5] Funded under the Canada–Manitoba agri-food subagreement of Economic Regional Development Agreement (ERDA).

[6] On a transfer of work to Plant Breeding Institute, Cambridge, England, April–December 1987.

[7] Appointed 4 May 1987 as head of Cereal Diseases Section.

[8] Appointed 13 July 1987.

[9] Appointed 14 October 1987 as a biologist under the Canada–Manitoba agri-food subagreement of Economic Regional Development Agreement (ERDA).

[10] Appointed 21 December 1987.

INTRODUCTION

Research programs at the Winnipeg Research Station focus on three main areas of responsibility: the development of improved cultivars of cereals specifically adapted to the rust area of the eastern prairies; research on the integrated control of insect pests of field crops; and research on the protection of stored cereals, oilseeds, and their products. In each of these areas, interdisciplinary teams of scientists are pursuing both mission-oriented and basic research.

The development of improved cereal cultivars requires the close collaboration of breeders, geneticists, cytogeneticists, plant pathologists, and cereal chemists. As a result of such collaboration, a new oat cultivar, Robert, was registered in 1987. Robert is the first oat cultivar to combine high tolerance for barley yellow dwarf virus with resistance to stem rust, crown rust, and smut. The identification of new virulent races of cereal rusts and the increasing incidence of other fungal and viral diseases emphasize the importance of maintaining a strong interdisciplinary team in cereal cultivar development. The continuing effectiveness of this approach is evident from the fact that in 1987, 90% of the area sown to hard red spring wheat across the prairies was sown to cultivars developed at the Winnipeg Research Station.

Research on the integrated control of field crop insects, particularly those that attack canola and the various special crops grown in southern Manitoba, includes the biology and ecology of pest species, the evaluation of biological and chemical control measures, the assessment of economic damage, and the development of integrated management systems. Recent advances in this regard include the patenting of eight strains of *Bacillus thuringiensis* for control of the bertha armyworm on canola and evidence for increasing the resistance or tolerance of this host to attack by flea beetles through the recurrent selection of plants surviving exposure to heavy populations of this pest.

Our research on the storage and protection of cereals, oilseeds, and their products is national in scope and involves close cooperation with the Canadian Grain Commission, the Food Production and Inspection Branch of Agriculture Canada, and the grain industry. Particular emphasis is being placed on understanding the ecology of organisms infesting stored grain, the development of safe storage guidelines, chemical and physical measures to control infestations, and the microbiological and environmental factors influencing the occurrence of mycotoxins. Attention is being focused on controlling storage insects with minimal use of toxic chemicals and improved means of detecting infestations.

During 1987 the Manitoba Branch of the Canadian Seed Growers' Association awarded Dr. D.R. Metcalfe, barley breeder, an honorary life membership for his outstanding contribution to the seed industry. Dr. D. Leisle and Dr. R. Rohringer stepped down from their position as section head and were replaced by the appointment of Dr. D. Brown as head, Cereal Breeding Section, and Dr. J.W. Martens, as head, Cereal Diseases Section, respectively. The following key staff members retired after long and productive careers at Winnipeg: Dr. S.R. Loschiavo, stored product entomologist; Dr. G.H. Wylie, insect parasitologist; Mr. W. Romanow, insecticide biologist; and Mr. M.D. Hamilton, administrative officer. The following persons joined the staff: Dr. J. Kolmer, as rust pathologist; Mr. J. Anderson, as computer systems manager; Dr. P. Pachagounder, as entomologist (insect–plant relationships); and Mr. G. Johannson, as administrative officer. Staff members were saddened by the death of Mr. W. Ostapyk, a long-time technician in the Cereal Diseases Section, who died shortly after his retirement.

The following is a brief summary of research carried out in 1987. Further information can be found in our annual *Research Update* or in the publications listed here, copies of which can be obtained by writing to individual scientists or to the Research Station, Research Branch, Agriculture Canada, 195 Dafoe Road, Winnipeg, Man. R3T 2M9; Tel. (204) 269-2100.

T.G. Atkinson
Director

BREEDING, GENETICS, AND CYTOGENETICS

Barley

In the breeding program, emphasis was placed on incorporating new sources of disease resistance. Crosses involving the stem rust resistance source PI382313 were advanced to the F_4 generation; crosses involving rot root–spot blotch and net blotch resistance sources C2-83-6-12, ND7556, and Bowman were advanced to the F_5 generation; and backcrossed lines involving the net blotch resistant line CI9214 were advanced to the F_4 generation. Both two- and six-row lines possessing the *Un8* gene for loose smut resistance were advanced to the co-op tests. Populations from backcrosses to incorporate resistance to scald (using the *Turk* gene) and to BYDV (using the *YD2* gene) were advanced to the F_3.

A total of 39 892.5 ha (0.8% of the total area sown to barley on the prairies) of the recently registered two-row malting barley, Ellice, were planted in 1987. Norbert, a two-row feed barley released from the Winnipeg Research Station in 1980, was planted on 54 756 ha (1.2% of the total barley area) in 1987.

Peroxidase levels were examined in normal and low-polyphenol barley lines. The low polyphenol barleys appear to have at least double the peroxidase activity. This increase in enzyme activity may be responsible for the reduced polyphenol levels. Low polyphenol mutants derived from Ellice were evaluated in yield trials in 1987. Additional populations involving this low polyphenol characteristic were advanced to the F_3.

Hard red spring wheat

Several new backcrossing programs to incorporate disease resistance were initiated in 1987. Tan spot resistance, derived from 7990-244A, is being introduced into Katepwa and Roblin. Roblin was also used as the recurrent parent in backcrosses involving BW553 and RL4596 as sources of bunt resistance and 228III and 7411 as sources of root rot resistance.

Just over 729 ha of all classes of pedigreed seed of the recently registered cultivar Roblin were inspected in 1987. Of the total prairie area sown to bread wheat in 1987, 90% was planted to cultivars released from the Winnipeg Research Station.

Seven of 15 *Aegilops squarrosa* L. accessions were shown to possess genes for leaf rust resistance other than *Lr21* and *Lr32*. These new accessions may now be used to transfer additional genes for leaf rust resistance from this diploid to hard red spring wheat. It has been demonstrated that the closely linked genes for stem rust and adult-plant leaf rust resistance transferred from *A. speltoides* to Marquis (RL5711) are located on chromosome 2B. The gene for seedling leaf rust resistance, *Lr32*, was located on the short arm of chromosome 3D, 26.8 ± 4.0 crossover units from the centromere. Male transmission of telocentric 3DS in competition with complete 3D was 23.2%.

An inheritance study of leaf rust resistance in two Canadian cultivars, Columbus and Kenyon, showed that both have leaf rust resistance genes *Lr13* and *Lr34*. The gene for leaf rust resistance transferred from two Ethiopian durum wheats to hard red spring wheat was shown to be *Lr16*. This is the first successful transfer of a leaf rust resistance gene from a tetraploid to a hexaploid, and it involved a gene already present in the hexaploid.

The high molecular weight (HMW) glutenin subunit composition of 70 Canadian-grown wheat cultivars was determined by sodium dodecyl sulfate–polyacrylamide gel electrophoresis (SDS–PAGE). Variations in HMW protein account for 59–69% of the breadmaking quality of these cultivars. In conjunction with this study, unique HMW glutenin subunits previously uncataloged were found in three cultivars.

Canada prairie spring wheat

In the recently initiated breeding program for prairie spring (triple medium) wheats, supported by the Canada–Manitoba agri-food development trials subagreement, 12 new four-way crosses were made to develop a triple medium wheat. Over 15 000 F_3 to F_7 lines were screened for resistance to leaf rust, stem rust, loose smut, bunt, and after-ripe sprouting. Over 800 cultivars or lines were tested in yield trials including 16 lines in the eastern prairie high yield B; three entries in the B test were considered good enough, with better yield and earlier maturity than HY320, for entry into the 1988 high yield co-op test.

Durum wheat

The program continues to focus on selecting for early maturity, height, rust resistance, and head type. Fifteen single and three-way crosses were made; selections were made among 45 000 F_2 plants and 13 500 F_3 to F_6 lines. Almost 500 lines were screened in yield tests; of the six lines in the 1987 co-op test, two were retained to be tested for a 2nd year.

Based on a combination of agronomic traits and sprouting resistance, four lines were used in crosses to develop cultivars with postharvest sprouting resistance. These lines had sprouting values of 2, 8, 8, and 14% compared with 7 and 28% for RL4137 (the best source of this trait) and Medora, respectively.

Twenty-four percent of the area seeded in 1987 to durum wheat on the prairies was planted to cultivars released from the Winnipeg Research Station.

An analytical procedure using gas liquid chromatography has been developed for the microdetermination of some plant sterols including cholesterol. Sterol content determined by the new method was generally higher than that from the official method, indicating superior recovery. The analysis is simple, sensitive, and economical of time and solvent. Because the determination of the sterol components, particularly cholesterol, is important in a wide range of food products, this new method will have significance in the food industry.

Oats

Robert, a new common oat cultivar, was registered in 1987 and will be available to Secan Association seed growers for increase in 1988. This cultivar has tan-colored hull and a groat yield equal to Dumont. Compared with Dumont, it has better lodging resistance, is 2–3 days earlier in maturity, has a lower percentage of hull, and a higher percentage of protein. It is the first oat line combining tolerance for barley yellow dwarf virus (BYDV) with resistance to stem rust, crown rust, and smut.

Eighteen crosses were made to develop superior oat cultivars, and selections were made among 9700 F_4 to F_8 lines. Nearly 900 cultivars and lines were tested in yield trials including nine in the western co-op test. Two lines, OT239 and OT244, have been in the western co-op test for 4 and 3 years, respectively; current data indicate that these high-yielding, large-kerneled lines are not sufficiently better than Dumont or Robert to be advanced for registration.

Over 36% of the area seeded to oats on the prairies was planted to cultivars released from the Winnipeg Research Station.

Twenty-two high yielding lines carrying the stem rust resistance gene *Pg-16* were grown for a 2nd year in a preliminary yield trial. Results indicated that high-yielding lines carrying *Pg-16* can be selected, and that this very effective gene, originally identified in a tetraploid *Avena barbata* collection from Israel, can be used in the Winnipeg oat-breeding program.

CEREAL DISEASES

Much of the work in cereal pathology is in support of the development of disease-resistant cereal cultivars that minimize yield losses caused by disease, improve grain quality, reduce grower input, and provide for a safer environment by avoiding the need for chemical pesticides. The work involves annual disease surveys, pathogen virulence analysis, screening of wild and cultivated cereal collections for disease resistance, identifying and isolating resistance genes, and evaluating breeder's lines. In addition, basic research in genetics, biochemistry, biotechnology, and ultrastructure of pathogens and host–pathogen interactions is carried out.

Cereal rusts

Occurrence in 1987. Wheat stem rust was of little significance in 1987. Although stem rust appeared early in the season, the weather was initially dry, delaying rust increase until the susceptible winter wheat crops were mature enough to escape serious infection. Wheat leaf rust was found on winter wheat in early June, became widespread, but caused little damage. Moderate infections occurred in Neepawa spring wheat, but there was no yield loss.

Oat crown and stem rusts were observed earlier than usual in 1987, but subsequent development was slow and uneven. The recommended cultivars Fidler, Dumont, and Riel are highly resistant to both rusts and remained rust free. Crown rust was mainly confined to the Red River Valley of Manitoba and occurred only in trace amounts in eastern

Saskatchewan. A survey for oat stem rust late in the season showed that this rust occurred continuously from Manitoba to eastern and southern Alberta.

Analysis of virulence. The virulence of the wheat stem rust population remained stable for 1987. Of nine virulence combinations that were identified, two isolates from Saskatchewan were new races. Race *C53* continued to predominate at 94% of all (393) isolates that were identified. From 350 wheat leaf rust isolates from both eastern and western Canada, 56 virulence combinations were identified. The increased level of virulence on resistance gene *Lr24* and traces of virulence on lines with gene *Lr26* may require some modification of the resistance breeding strategy. New international nomenclatural systems for describing races of both wheat leaf and stem rusts were developed.

Race *NA27* continued to dominate the prairie oat stem rust population. It was found continuously from Manitoba through southern Alberta. Several new races of oat stem rust were identified, but these were not significant. From Ontario, 70 virulence combinations of oat crown rust were identified, of which 16 were potentially dangerous and 11 were new ones. The new races are significant, because they attack plants with gene *Pc39*, which is one of the major genes currently used in resistance breeding. In Manitoba, five new races, which attack gene *Pc39* or *Pc38* and *Pc39* in addition to some of the new races from Ontario, were identified. This represents the largest number of potentially dangerous new isolates ever found in Manitoba in annual surveys.

Sources and transfer of rust resistance. Work continued to transfer the stem rust resistance genes *Sr2*, *Sr22*, *Sr26*, and *Sr33* into Columbus and Benito spring wheat. Further work was done to incorporate stem rust (*Sr24* and *Sr31*) and leaf rust (*Lr24* and *Lr26*) resistance into Norstar winter wheat.

Molecular biology. The presence of race-specific glycoproteins in intercellular washing fluids (IWF) from wheat leaves infected with stem rust was confirmed. A new blotting technique to detect enzymes in IWF was developed, and a patent for the method is pending. Other work involved a comparison of glycoproteins from IWF with those released from germ tube walls, and differences were noted. In permeability–plasmolysis studies, the germ tube walls were found less rigid than mycelial walls. Preliminary work to accomplish in situ transformation in the wheat stem rust fungus was done, using a yellow mutant of the fungus as a marker. Some problems with toxicity in the transforming environment were noted, and ways of avoiding them were indicated. Double-stranded RNAs from mitochondria of wheat, oat, and rye stem rust érediosporelings were characterized and compared. The results are used to elucidate the taxonomic status of these and other fungi.

Electron microscopy. The value of cryo-processing techniques for tissue preservation was demonstrated by improved preservation of mucilage around intercellular hyphal cells. The amount and conformation of the mucilage, analyzed cytochemically, varied with location in the fungal colony. These results are important in interpreting many aspects of rust–host interactions. The in situ location of some glyco-substances in the rust fungal–host interface was elucidated by probing with gold-labeled plant lectins.

Cereal smuts

Barley. Barley fields were surveyed for diseases caused by *Ustilago hordei*, *U. nigra*, and *U. nuda*. Smut was found in 81% of fields examined with a mean level of infection of 1.6%. Infection in one field attained a level of 40% covered smut, 4% false loose smut, and 2% loose smut, which demonstrates the potential damage that can result when susceptible cultivars are grown and control measures are ignored.

Wheat and oats. Surveys were conducted in Manitoba and eastern Saskatchewan. In hard red spring wheat, smut was found in 10% of 245 fields inspected, with a mean level of 0.02% (noninfected fields included) and a maximum level of 3% in a semidwarf cultivar. Because of reduced plantings of susceptible semidwarf cultivars in 1987, both incidence and level of infection were low. Of 63 fields of durum, 35% showed infection, with a mean level of 0.04% and a maximum of 0.5%. Of 34 oat fields, 17% showed either loose or covered smut, or both; infection ranged up to 1%, with a mean of 0.09%.

Field collections of smut from wheat in Canada, Turkey, and Pakistan were evaluated for their race composition. One new race was identified from each of these countries. Work was done to develop an international standard of nomenclature for races of loose smut of wheat.

Molecular biology. Physical maps of linear plasmids from mitochondria from seven isolates of *Tilletia* spp. were constructed using restriction enzymes and exonucleases. The plasmid from *T. contraversa* is not homologous to any ribosomal genes, or to any sequence in the total DNA of *Ustilago hordei* or *Puccinia graminis tritici*. Ribosomal DNAs from common and dwarf bunts of wheat, barley smuts, and wheat stem rust were mapped and compared with other fungal genera.

General pathology

Barley. The main leaf diseases other than rust were net blotch, spot blotch, and speckled leaf blotch. Of 45 six- and two-row barley fields surveyed, 51% had trace disease levels, 47% had slight disease levels, and 2% had moderate disease levels. The levels of net and spot blotch were lower in 1987 than in 1986. However, it appears that speckled leaf blotch is becoming more prevalent. The casual fungus *Septoria passerini* is stubble-borne, and the increased disease levels are probably due to the increased practice of minimum tillage. In screening tests, net blotch and scald resistance were detected in advanced breeders lines, and scald resistance was found for the first time in two-row barley. A number of lines in the western co-op tests were shown to have adult plant resistance to net blotch, which in one test was responsible for a 6% yield increase. Work on biotype distribution of the net blotch fungus showed this fungus to be much more variable than expected.

Wheat. Fusarium head blight continued to be a problem in southern Manitoba. Bread wheats were more commonly infected than in 1986, although disease severity remained low (<1%). The main problems are in durum wheats in the southern Red River Valley, where fields with up to 25% of heads infected were found.

Hard red spring, semidwarf, and durum wheats were surveyed for various leaf spot – blotch diseases. There were minimal yield losses in hard red spring wheats resulting from these diseases. In 1987 *Septoria avenae* blotch was more common than tan spot, which is the reverse of that normally found. Yield losses occurred in some fields of semidwarf wheat. Samples from these fields indicated effects of both virus and *Septoria* infections. Work to evaluate bread and durum wheat for tan spot resistance showed segregation for resistance in bread wheat. These results promise development of resistant bread wheat cultivars.

Viruses

The incidence and severity of barley yellow dwarf virus (BYDV), which attacks wheat, barley, and oats, were at historically high levels in western Canada. In some fields, virtually 100% of plants were infected. In some dry areas of Saskatchewan, yield losses were as high as 80–90%. In Manitoba, losses ranged from 10–15% on clay soils to 20–30% on sandy soils. An important advance was made by registering the oat cultivar Robert, which has higher BYDV resistance than any other oat licensed in Canada.

Flame chlorosis in barley remained confined to west-central Manitoba. The etiology of this new viruslike agent has now been characterized. Brome mosaic virus (BMV), newly discovered in wheat in Canada, remained limited in distribution. Tests on modes of transmission showed that only mechanical transmission spreads the virus, reducing the potential of BMV as a serious disease threat.

CROP PROTECTION

Research on insect pests of oilseeds, cereals, vegetables, and special crops emphasizes aspects of their biology and control leading toward better prediction of infestations, crop protection, and the reduction of pest populations. These programs are supported by research on sampling techniques, survival, development, phenology, host selection, induction, and termination of diapause, overwintering strategies, reproductive biology, and the biochemical bases of neurotransmission.

Monitoring and prediction

Yellow water traps baited with allyl isothiocyanate were evaluated for monitoring the seasonal activity and infestation potential of the cabbage maggot, *Delia radicum* (L.), on rutabaga. The activity peak for the overwintering generation occurred on Julian day 159 ± 4.1 (mean ± standard deviation), with degree day (DD) accumulations, base 5°C, of 159 ± 6.2 for soil at 5 cm and 387 ± 69.4 for air. The activity peak for the first generation occurred at day 224 ± 11.7, with DD accumulations of 981 ± 229.3 and 1295 ± 175.7 for soil and air, respectively. Correlations between number of females trapped per week and number of eggs in soil samples from around plants were generally not significant. A regression of number of eggs on females trapped was significant, but had a low coefficient of determination ($r^2 = 0.289$). The traps are adequate for monitoring seasonal activity, but are unreliable as quantitative indicators of potential infestation.

As part of a project funded under the Canada–Manitoba economic and regional development agreement, the distribution and damage caused by selected insect pests of field crops in Manitoba was determined. Root maggots (*Delia* spp.) and *Lygus* bugs damaged canola throughout the province in 1987. From 0 to 82% of canola roots in 40 fields showed damage (mostly light) caused by root maggots. *Lygus* bugs damaged an average 16% of the seeds in the pods (range, 7–49%) in the same fields. The European corn borer, *Ostrinia nubilalis* (Hübner), was found in all fields surveyed in south-central Manitoba.

Damage assessment

Foliar feeding by the red-backed cutworm, *Euxoa ochrogaster* (Guenée), on field corn provided a good early indicator of the presence of cutworms, but the amount of foliar damage could not be used to predict crop loss. The amount of plant loss per cutworm varied annually, and therefore cutworm density also was not a reliable estimator of loss. However, yield per plant did not increase when plant stands are thinned by cutworms, and therefore plant loss was directly related to yield loss. Routine monitoring of plant losses could be used to determine the need for cutworm control.

Biological control

Collections of parasitized pea aphids, *Acyrthosipon pisum* (Harris), from alfalfa fields in the Red River Valley were small because of a fungal epidemic among the aphids. Only 8 of 976 parasitized mummies contained the recently introduced *Aphidius smithi* Sharma & Subba Rao, and these were collected at a 1987 release site.

Nearly 16 000 flea beetles (*Phyllotreta* spp.) were collected from canola fields near Glenlea and Dauphin, the sites of previous releases of the parasitoid *Townesilitus bicolor* (Wesm.). None of the beetles were parasitized by this species.

In 1987, 565 male and 1387 female *Eurithia consobrina* (Mg.) were released near Dauphin against the bertha armyworm, *Mamestra configurata* Walker. Larvae collections of bertha armyworm and armyworm, *Pseudaletia unipuncta* (Haworth), from the vicinity of the 1985 and 1986 releases (Swan River Valley) did not contain *E. consobrina*.

The parasitoids *Banchus flavescens* Cress. and *Athrycia cinerea* (Coq.) and a nuclear polyhedrosis virus (NPV) were the only natural enemies that occurred consistently in bertha armyworm larvae from 1973 to 1986. The NPV was associated with the termination of five local outbreaks of the host.

Lines of canola, *Brassica napus* L., subjected to recurrent selection in previous years, had substantially lower susceptibility to flea beetle (*Phyllotreta* spp.) damage than the widely grown cultivar Westar. Susceptibility to damage was measured by determining seedling survival. Similarly, selected lines of *B. campestris* L. had lower susceptibility to flea beetle damage and grew much more vigorously when heavily infested by flea beetles than did the standard cultivar Tobin.

Insecticides

Drench treatments of carbofuran were not effective for control of cabbage maggot on rutabaga, even at 10 times the recommended rate. Efficacy was not enhanced by delivering the treatment in greater volumes of water. Desanit gave significant reduction in damage when applied at the recommended rate, but twice this rate was required to provide control that is commercially acceptable (over 80% marketable roots).

The eight best strains of *Bacillus thuringiensis* Berl. among the 113 strains bioassayed for efficacy against bertha armyworm larvae were patented for use against this species in Canada. A similar patent application has been filed in the United States. These patents are granted as a prelude to further development of the most toxic strain for commercial use.

Biology and physiology

Methods of rearing the redbacked cutworm with controlled growth rates and with 90% survival from egg to adult were developed.

Precise timing of rearings is possible, as eggs are viable for 14 months and hatch within 24 h when removed from cold storage after dormancy has been broken.

Eupyrene spermiogenesis and spermatozoa production in the bertha armyworm were inhibited by temperatures greater than 24°C during a critical period of about 7 days during the first half of postdiapause pupal–adult development, the result of irreversible autolysis of the early- and mid-stage eupyrene spermatids. The critical period coincided with the appearance of early-stage eupyrene spermatids. These temperatures had no effect on eupyrene spermatogenesis if they occurred before or after the critical period.

Taurine (2-aminoethane sulfonate) and the taurine analogue, guanidinoethane sulfonate, interact with octopamine receptors to decrease octopamine-stimulated cyclic AMP production. Sublethal doses of certain insecticides provoke octopamine release from the central nervous system (CNS), which is counteracted by induced increases in the level of taurine in the blood. Lethal doses provoke a massive release of octopamine. Neurochemical regulation in the CNS is overwhelmed, physiological regulation is no longer possible, and the insect dies. Techniques were developed for the preparation of relatively pure, morphologically well-preserved, and functionally competent synaptosomes (pinched-off, resealed nerve endings) from the insect brain, which were used in vitro to study voltage-dependent and adenosine-triphosphate-dependent calcium ion transport. Insect brain calcium transport systems were shown to have a high affinity for free calcium ions relative to vertebrate brain, indicating possible target sites for insecticides that disrupt calcium ion transport.

Egg development in the red turnip beetle, *Entomoscelis americana* Brown, is initiated within the first 3 days after emergence from aestivation. Egg laying begins soon after the first eggs are developed, usually within the first 8 days after emergence. The rate of egg laying reaches a peak within 2 weeks after the initiation of egg laying and then declines gradually, ceasing a few days before death of the females. Almost all eggs were laid between mid August and mid October. The average number of eggs laid per female ranged between 254 and 426 in three studies.

PROTECTION OF STORED PRODUCTS

Research on the biology and control of pests in stored cereals and oilseeds and their by-products emphasizes the interaction of insects, mites, and microorganisms in a dynamic storage environment. The program includes studies of management of grain-storage systems; factors that lower the quality of grain during long-term storage; survey, prediction, and control of microflora and mycotoxins in stored cereals and oilseeds; identification and quantification of insects and mites in stored products; influence of attractants and feeding stimuli on insect behavior; and control of insects and mites by environmental, physical, and chemical means.

Storage ecology

Physical and biological changes occurring during ventilation of tough to damp-stored wheat were monitored in a low-temperature, grain-drying facility at Winnipeg. The effects of weather conditions, ventilation rates, initial moisture content of the grain, and fan control strategies on the movement and shapes of moisture fronts in ventilated wheat bulks were investigated in bins 0.61 and 1.22 m in diameter for 3 harvest-years. Results indicated that speed of the drying fronts was not linearly proportional to airflow rate. A doubling of airflow resulted in an increase, of up to 2.5 times, in drying front speed. The drying front speed appeared to be unaffected by periods of high humidity.

Microflora and mycotoxins

In 1985 abnormally high summer rainfall in southern Manitoba resulted in a high incidence of fusarium head blight symptoms in some samples of wheat delivered to primary elevators. *Fusarium* species were found in 48 of the 53 samples examined, with *F. graminearum* Schwabe in 30, *F. sporotrichioides* Sherb. in 38, *F. poae* (Peck) Wollenw. in 21, *F. acuminatum* Ell. & Ev. sensu Gordon in 21, *F. avenaceum* (Fr.) Sacc. in 21, and *F. equiseti* (Corda) Sacc. sensu Gordon in 25. The mycotoxin deoxynivalenol was found in 40 samples, diacetoxyscirpenol in 20 samples, HT-2 toxin in 10 samples, and T-2 toxin in 11 samples.

During one autumn to summer period, the fungal odor compounds 3-methyl-1-butanol, 1-octen-3-ol, and 3-octanone were monitored at Winnipeg in nine experimental bins containing a hard red spring wheat. All three odor compounds occurred in considerably greater amounts in bulk wheat in nonventilated than in ventilated bins, particularly in those with wheat having 18.2% moisture content. The presence of these compounds usually coincided with infection of the seeds by the fungi *Alternaria alternata* (Fr.) Keissler, *Aspergillus repens* DeBarry, *A. versicolor* (Vuill.) Tiraboschi, *Penicillium crustosum* Thom, *P. oxalicum* Currie & Thom, *P. aurantiogriseum* Diercks, and *P. citrinum* Thom.

Biology

A distribution study of stored-product and other insects in unswept, empty farm granaries was conducted over 4 years. Thirteen species of stored-product insects were found in Manitoba and Saskatchewan and 12 in Alberta. The most common was the American black flour beetle, *Tribolium audax* Halstead, followed by the rusty grain beetle, *Cryptolestes ferrugineus* (Stephens), and the yellow mealworm, *Tenebrio molitor* Linnaeus. Nine fungus-feeding species were found in Manitoba, 12 in Saskatchewan, and 12 in Alberta. Five nonstored-product species of insects that were scavengers or predators, or were sheltering in the granaries, were found in Manitoba, 31 in Saskatchewan, and 10 in Alberta.

Vulnerability of seven wheat cultivars to nine major species of stored-product beetles was determined by measuring multiplication rates on whole and crushed seeds at 30°C and 70% relative humidity (RH) for 12 weeks. Susceptibility of a cultivar to an insect was assumed to be proportional to the multiplication of that insect. Vulnerability of cultivars varied considerably, depending on the insect species infesting the seed. Whole seeds and cultivars with greater kernel hardness generally were less susceptible to insects except for weevils, *Sitophilus* spp., and the lesser grain borer, *Rhyzopertha dominica* (Fabricius). Generally, soft wheat cultivars grown in western Canada, such as Fielder and Owens, are at a greater risk of postharvest insect damage than hard red spring cultivars. HY320, which is intermediate in kernel hardness, may be prone to insect infestations.

An energy budget was developed for all life stages of the larger grain borer, *Prostephanus truncatus* (Horn), reared singly on whole corn kernels at 30°C and 70% RH. The mean energy content of one corn kernel was 4537 joules (J). A mean of 547 J was removed by larval feeding, of which 252 J was estimated to be consumed. Adults consumed an estimated 1128–4210 J over a lifespan of 45–168 days. Cumulative assimilation efficiency was 47.2%, gross production efficiency 16.0%, and net production efficiency 34.0%.

Control

Adult rusty grain beetles were exposed to CO_2–O_2 levels of about 95–2%, 75–6%, and 60–10%, respectively, at 2.5, 10, and 20°C. Exposures of less than 1 week were not effective in controlling the insects in laboratory tests. Reproduction of recovering adults was affected by length of exposure to elevated CO_2 levels. Extrapolation from laboratory data indicates that control of *C. ferrugineus* in granaries holding wheat will require initial CO_2 levels near 94%, with O_2 levels below 1% for practical fumigation in 1 week at temperatures near or below 10°C, although lower levels of CO_2 will be effective above 20°C.

Malathion resistance in a strain of the red flour beetle, *Tribolium castaneum* (Herbst), was found to be malathion specific, triphenyl phosphate suppressible, autosomal, monofactorial, and semidominant after 15 generations of selection on up to 600 ppm malathion in flour. At present, control failures with malathion should be rare, because frequency levels of malathion-resistant strains of *T. castaneum* in Canada is low, and immigration of susceptible adults will raise the proportion of heterozygous or susceptible progeny.

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[2] Ph.D. trainee.

INTRODUCTION

The Melfort Research Station was established in 1935 to serve the needs of crop and livestock producers in the Aspen Parkbelt of northeastern Saskatchewan, an area comprising 10% of Canada's improved agricultural land. It is well suited to the production of a wide range of cereal, oilseed, pulse, and forage crops and to the production of beef cattle and pigs. The station's nine scientists include cereal, oilseed, pulse, and forage crop agronomists, a soils specialist, a weeds specialist, a plant pathologist, an engineer, a ruminant nutritionist, and a beef cow–calf pasture management specialist involved in interdisciplinary research aimed at improving the efficiency of crop and livestock production. Research areas include forage production, harvesting, storage and utilization, beef cow–calf management, pasture production and utilization, and cereal, oilseed, and pulse crop production. Numerous cooperative research projects are undertaken with the province, the agriculture industry, and producer groups, whose support is appreciated.

During the year Mr. Ken Bowren retired after 40 years of service to Agriculture Canada at the Melfort Research Station in his capacity of agronomist and program leader. Dr. Berkenkamp, plant pathologist, transferred to Melfort from Lacombe and Dr. Bittman, forage crop agronomist, transferred to Agassiz.

The station publishes *Research Highlights* annually; that publication and any other information relating to our work can be obtained by writing to us at Box 1240, Melfort, Sask. S0E 1A0; Tel. (306) 752-2776.

S.E. Beacom
Director

CEREAL, OILSEED, AND SPECIAL CROP PRODUCTION

Effect of seed rate and row spacing on wheat yield

Increasing seed rate and decreasing row spacing increased the yield of HY320 and Neepawa spring wheat in 1986 and 1987, both abnormally dry years in northeastern Saskatchewan. A seed rate of 200 kg/ha yielded 260 kg/ha, or 15% more than the 40 kg/ha rate. The narrowest row spacing, 9 cm, yielded 190 kg/ha, or 11% more than the 36-cm spacing. In comparison with a common combination of seed rate and row spacing, 80 kg/ha and 18 cm, neither an increase in seed rate nor a decrease in row spacing alone increased yield, but the combination of 9-cm row spacing and 200 kg/ha seed rate increased yield by 160 kg/ha, or 8%.

The effect of varying seed rate and row spacing was greater for Norstar and Norwin winter wheat than for the spring wheats, presumably because winter wheat makes better use of limited spring moisture. Increasing seed rate from 35 to 140 kg/ha increased yield by 28%, or 600 kg/ha. Decreasing row spacing from 36 to 9 cm increased yield 11%, or 230 kg/ha. The net effect of halving row spacing and doubling seed rate was a yield increase of 670 kg/ha, or 23% over the conventional practice, 18-cm row spacing and 70 kg/ha seed rate.

New faba bean cultivar

Orion, an early maturing faba bean was registered. It is adapted to short-season areas of the parklands of western Canada, and yields better than other cultivars in this area. The early maturity of Orion helps to avoid difficult harvesting and losses in years with wet fall weather. Being short and early, it is not a high forage producer.

Crop diseases

In a survey of alfalfa diseases in northeastern Saskatchewan, common leaf spot was found in all fields and affected 14% of the leaf area. Black stem affected 80% of the fields and 6% of the stem area; yellow leaf blotch, 70% of fields and 2% of the leaf area; stagonospora leaf spot, 40% of fields and (along with pepper spot and downey) less than 1% of the leaf area.

Alfalfa cultivars, for the dehydration industry, were evaluated for their resistance to brown root rot and leptosphaerulina leaf spot. Pacer was the most susceptible to brown root rot, followed by Anchor, then Apica, with

Beaver and Algonquin the least resistant and Peace, the most resistant. The same cultivars arranged in order of increasing resistance to leptosphaerulina leaf spot were Beaver, Pacer, Algonquin, Peace, Anchor, and Apica.

Seeding methods for HY320

The effect of hoe drill, with and without pre-seeding tillage, and discer seeding at four levels of N fertility on yield of HY320 and Neepawa wheat, was tested in a 3-year study. The hoe drill with pre-seeding tillage, hoe drill without tillage prior to seeding, and the discer treatments yielded 2820, 3092, and 3129 kg/ha, respectively. HY320 yielded 3491 kg/ha, and Neepawa yielded 2536 kg/ha. There was little effect of seeding method on Neepawa, but the hoe drill with tillage reduced the yield of HY320.

Both cultivars had a similar response to N fertilization, with an N rate of 56 kg/ha increasing yields by 11%.

Weed control

Residues of AC 222 293, applied at a rate of 1 kg/ha to the previous year's wheat crop on Melfort silty clay loam, reduced foliage dry-matter yield of lentils by 28% but had no adverse effect on peas, canola, alfalfa, red clover, and sweetclover. The rotational crops were also unaffected when planted after wheat treated with clopyralid (0.2 kg/ha) or after Tobin canola treated with DPX A7881 (0.6 kg/ha), metribuzin (0.42 kg/ha), cyanazin (2.4 kg/ha), and terbutryn (1.0 kg/ha).

BEEF–FORAGE PRODUCTION SYSTEMS

Forage crops

Evaluation of forage cultivars under pasture conditions. A comparison of alfalfa cultivars growing in mixture with smooth bromegrass demonstrated that a yellow-flowered strain (SCMF3713) yielded more than currently recommended cultivars beginning in the 4th year of harvest. After 7 years this strain had 50% greater yield and 100% more persistence than any other cultivar under both hay and pasture harvesting and both high and low soil phosphorus. Examination of uniform cultivar test data (19 tests averaging 5.4 years) showed a statistically significant improvement in yield (82–96%) by SCMF3713 compared with Rambler over the course of these tests. Thus, when evaluating alfalfa cultivars for pasture, they should be tested in the appropriate mixture over a period comparable to the life of the pasture stand. Rebound, a cultivar of smooth bromegrass, yielded as much as Carlton but had 50% more leaf material and 2.3% greater digestibility. Meadow bromegrass had 7% more total production, 15% more regrowth after first cut, and 65% more fall production than smooth bromegrass.

Weed control. The effects of repeated fall applications of metribuzin, hexazinone, and terbacil and spring applications of sethoxydim and fluazifop were studied on established alfalfa, red clover, alsike clover, birdsfoot trefoil, sainfoin, and cicer milkvetch. All legumes exhibited excellent tolerance for the graminicides. Alfalfa was the most tolerant and alsike clover the least tolerant to the residual herbicides. Forage dry-matter yields of alsike clover were reduced 21, 29, and 25%, respectively, by metribuzin, hexazinone, and terbacil treatments. The total yield of sainfoin over a 3-year period, however, increased 12 and 18%, respectively, with hexazinone and terbacil treatments.

Spring applications of hexazinone and metribuzin at 1 kg/ha to dormant established alfalfa increased seed yields by 48 and 66%, respectively. Seed yields from plots treated with chlorsulfuron (22 g/ha) and imazethapyr (125 g/ha) averaged 341 and 321 kg/ha, respectively, whereas the 1986–1987 average for the untreated plots was 221 kg/ha. Imazethapyr, selective on seedling and established forage legumes, provided satisfactory control of cleavers species.

Crop and crop by-product utilization

Beef cows fed straw-based rations. In a 5-year study, early-calving (February) cows fed barley straw ad libitum plus silage and grain consumed 10.8 kg of dry matter (DM) daily, whereas late-calving (April) cows consumed 9.84 kg. Straw consumption was 4.5 and 4.9 kg/day for early-calving Angus (A) × Hereford (H) and Simmental (S) × Hereford (H) cows, and 4.9 and 5.7 for late-calving cows of the two breeds, respectively. Initial weights of the early- and late-calving A × H and of the early- and late-calving S × H cows were 554, 517, 579, and 551 kg, respectively. Corresponding weight losses were 42, 18, 49, and 22 kg. Initial ultrasonic back-fat measurements for A × H and S × H cows were 8.8 and 4.2 mm, respectively. At calving they were 7.1 and 2.9 mm and at the conclusion of the trial 5.2 and 1.9 mm, respectively. Average fall weaned weights for early-born calves were 242.8 kg and for late-born calves, 190 kg.

Kochia as a potential feed source for ruminants. Saskatchewan and Texas strains of kochia were grown on moderately saline soil and harvested as hay at 18–20% moisture in early and late August. The Texas strain does not flower or set seed in our environment, whereas the Saskatchewan strain flowers readily and produces abundant seed. Kochia dry-matter yields averaged 2.6 and 7.2 t/ha for early and late cut, respectively, with little difference in yield between the strains. Complete alfalfa-based (16.7% crude protein) diets with kochia (9.5% crude protein) added at 0, 25, 50, and 75% were used to determine the voluntary intake and nutrient digestibility by sheep. In addition, diets containing 50% kochia or alfalfa supplemented with barley were also compared. The results suggest that kochia can be incorporated into high forage or concentrate ruminant diets at levels of up to 50% of the diet without an adverse effect on intake or digestibility.

Pea screenings in steer finishing rations. Adding 8% of pea screenings (19% crude protein (CP), 92% digestible organic matter) to a crested wheatgrass silage ration (39% dry matter, 13.2% CP) followed by a dry-rolled barley-based ration (11% CP) increased rate of gain by 9% (1.13 versus 1.03 kg/day), reduced feed required per unit gain by 7%, increased dressing percentage by 1.2 percentage points, and increased returns to labor by $25 per head compared with feeding the same ration combination without peas. Pea-fed cattle reached heavier weights (557 versus 546 kg) before reaching finished condition (6.9 versus 7.1 mm back fat). With rapidly increased field pea hectarage, the availability of pea screenings at a reasonable cost (11 cents per kilogram) presents an opportunity to the beef-feeding industry.

Antibiotics as feed additives in lamb diets. Two studies were conducted with a complete ground alfalfa diet with the following treatments: nonmedicated control (CON); monensin (MON, 11 mg/kg DM); chlortetracycline (CTC, 11 mg/kg DM); tylosin (TYL, 10 mg/kg DM); MON + CTC (11 mg MON/kg DM + 11 mg CTC/kg DM); MON + TYL (11 mg MON/kg DM + 10 mg TYL/kg DM). An 85-day production study with weaned lambs (20 kg) and a digestibility study with mature wethers were conducted. There were no significant differences in DM intake or average daily gains among treatments. Feed efficiency was reduced ($P < 0.05$) with CTC when compared with CON (6.22 versus 5.68). Mean digestibilities of DM, acid detergent fiber, and neutral detergent fibers were significantly ($P < 0.05$) reduced for all treatments when compared with CON. Protein digestibility was significantly increased (66.3 versus 70.9%) with MON, and energy digestibility was significantly reduced with TYL. Rumen ammonia and volatile fatty acid (acetic, propionic, and butyric acids) concentrations were not significantly influenced by the treatments. These results suggest that MON, CTC, and TYL were not effective supplements for lambs offered complete, ground alfalfa diets. Good-quality forage, processing (grinding) of the diet, and good health of the animals used were perhaps the reasons these antibiotics were not beneficial.

Calving management

Effect of post partum nutrition. Good postpartum nutrition was as effective in getting cows to conceive earlier as was the use of Syncro-Mate-B or Estrumate, or weaning calves for 48 h at the start of the breeding season. Pregnancy checking showed no significant differences between the treatments. Before 1986, cows calved either from mid January to the end of February or from mid March to mid May. During the study the cows were bred at 35 days or more, postpartum. By the end of the 2nd year cows that previously calved in April and May were calving in February and March.

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Research Station
Regina, Saskatchewan

PROFESSIONAL STAFF

J. Dueck,[1] B.S.A., M.Sc., Ph.D.	Director
M.G.G. Blair	Administrative Officer
J.D. Wilson, B.S.A.	Information Officer
R.M. Young, Dip.Admin., B.Sc.	Systems Manager – Analyst
S.P. Yanosik	Library Technician

Biological Control of Weeds

P. Harris, B.S.F., D.I.C., Ph.D.	Head of Section; Insects
R.M.D. Makowski, B.Sc., M.Sc., Ph.D.	Plant pathogens
K. Mortensen, B.Sc., Ph.D.	Plant pathogens
D.P. Peschken, B.S.A., M.Sc., Dr.Sci.Agr.	Insects

Weed Ecology and Physiology

G.I. McIntyre, B.Sc., Ph.D.	Head of Section; Physiology, water relations, dormancy
G.G. Bowes, B.S.A., M.Sc., Ph.D.	Range and pasture weed control
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L. Hume, B.Sc., Ph.D.	Crop losses, ecology
J.H. Hunter, B.S.A., Ph.D.	Weed control – annual crops
A.G. Thomas, B.Sc., M.Sc., Ph.D.	Surveys, ecology
R.F. Wise	Computer Programmer

Herbicide Behavior in the Environment

R. Grover, B.Sc., M.Sc., Ph.D.	Head of Section; Availability, mobility
A.J. Cessna, B.A., Ph.D.	Residues, plants
D.A. Pchajek, B.S.A., M.Sc.	Application technology (Economic Regional Development Agreement)
A.E. Smith, B.Sc., Ph.D., D.Sc., F.C.I.C.	Residues, metabolism, soil

Experimental Farm, Indian Head, Saskatchewan

G.R. Boughton, B.S.A., M.Sc.	Officer-in-Charge; Seed increase
D.A. Derksen, B.S.A.	Agronomy, special crops
G.P. Lafond, B.A., B.Sc., M.Sc., Ph.D.	Agronomy, cereal crops

Departures

M.G. Maw,[2] B.Sc., M.Sc.	Biological control of weeds
T.F. Townley-Smith,[3] B.Sc., M.Sc., Ph.D.	Director

VISITING SCIENTISTS

M.A. Jasieniuk, B.Sc., M.Sc., Ph.D. Postdoctoral fellow	Weed ecology
M.V.S. Raju,[4] B.Sc., M.Sc., Ph.D.	Seed structure and development
R.J. Deschamps,[5] B.Sc., M.Sc. Graduate student	Wild oat herbicides

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[1] Returned from secondment to Canadian International Development Agency, Barani Agricultural Research and Development Project, Islamabad, Pakistan, 31 August 1987.

[2] Retired 31 January 1987.

[3] Acting Director, 12 August 1985 to 31 August 1987.

[4] On sabbatical from 1 July 1986 to 30 June 1987, Department of Biology, University of Regina, Regina, Sask.

[5] Graduated with an M.Sc. degree August 1987.

INTRODUCTION

The program of the Regina Research Station focuses on the biology and control of weeds in cultivated crops and pastures and the chemistry of herbicides in the environment. The extensive use of herbicides in prairie agriculture has created a demand for scientific information on efficacy, crop tolerance, persistence in soil, and movement away from the intended target. In recent years the program has also examined exposure hazards to herbicide sprayer operators and has successfully developed means to minimize hazards in handling herbicides. The program has developed methodology to account for the mass balance of applied herbicides. A project to develop technology for improved application of herbicides is funded under a Canada–Saskatchewan Economic Regional Development Agreement (ERDA). New technology is being developed for the use of plant pathogens and insects, as an alternative to herbicides, for the control of weeds.

In addition to weed research, the station contributes to the south Saskatchewan wheat-breeding program. New cultivars of cereals, oilseeds, and pulse crops are evaluated for adaptability. Agronomic experiments develop new information for crop management.

Indian Head Experimental Farm research programs include cereal and special crop agronomy. The emphasis is on crop management and weed control, and includes projects partly funded by the ERDA and Hoechst Canada Inc.

The Seed Increase Unit is responsible for increase and distribution of new cultivars developed by Agriculture Canada and for a nursery for breeding plants in the winter, at Brawley, Calif.

One scientist, M.G. Maw, retired from the Biological Control Section after more than 35 years of service with Agriculture Canada. R.M.D. Makowski obtained her doctorate degree.

More detailed information on the station program may be obtained by directing enquiries to Research Station, Research Branch, Agriculture Canada, 5000 Wascana Parkway, P.O. Box 440, Regina, Sask. S4P 3A2; Tel. (306) 780-7400.

J. Dueck
Director

BIOLOGICAL CONTROL

Perennial sow-thistle

The leaf-gall fly, *Cystiphora sonchi* (Bremi), released in 1981, continues to spread and now occurs on 65 ha near Outlook and 25 ha near Pike Lake, Sask. This fly can pupate and complete a third generation in the fall, despite night frosts, and is thus adapted to the short season of the Canadian prairies. *C. sonchi* was released in Nova Scotia, where it became established. Host specificity studies on the leaf-mining fly, *Liriomyza sonchi* Hendel, were completed. From 0.04 to 0.67 adults per female were produced on the genera *Aetheorriza*, *Crepis*, *Leontodon*, and *Taraxacum* as compared with 23 on perennial sow-thistle. *L. sonchi* could also breed readily on other sow-thistle species. Ten cultivars of lettuce, *Lactuca sativa* L., were tested in no-choice tests, and one adult, or 0.006 per female, was produced. When *L. sonchi* had perennial sow-thistle as a choice it did not breed on lettuce. Thus, *L. sonchi* is restricted to sow-thistle in the field. The other plant species that were occasionally accepted in the laboratory are considered cage-induced hosts. First releases of *L. sonchi* were made in Saskatchewan.

Canada thistle

The only colony of the stem-gall fly, *Urophora cardui* (L.), on the prairies doubled in number and continued to spread on the release site in Saskatchewan, where a relatively hardy strain from New Brunswick and Finland was released. The dry climate does not prevent the adults escaping from the galls in spring, and breeding appears successful. The stem-mining weevil, *Ceuthorhynchus litura* (F.), causes a significant reduction in root carbohydrates in only 1 out of 3 years when measured in the fall. This agrees with the field observation that attacked thistles remain vigorous.

Scentless chamomile

Scentless chamomile was investigated for its suitability as a candidate for biological control. This introduced weed is difficult to control with herbicides and may reduce the yield of spring wheat up to 90%. It can form permanent, dense stands on roadsides, disturbed and cultivated areas around sloughs, and low, moist areas in fields from where it spreads. It also can invade pastures and hayland. Scentless chamomile contributes to the increased use of summerfallow and to the reduced production of noncompetitive crops such as lentils. Some potential biological control agents are available; preliminary tests have been conducted on one insect in Europe that appears to be a promising candidate. This weevil, *Apion hookeri* Kirby, seems to be host-specific, tolerant of climatic conditions similar to Canada, and is effective in destroying seeds. Two other insects and two disease organisms seem sufficiently host-specific to warrant further study. It is concluded that scentless chamomile is a good target for further research in biological control.

Round-leaved mallow

An endemic fungus, *Colletotrichum gloeosporioides*, causing anthracnose of round-leaved mallow has shown good potential as a biological herbicide. In field trials conducted at Regina and Indian Head, a concentration of 30–60 million spores per square metre in a water volume of 150 L/ha resulted in excellent control of round-leaved mallow in wheat and lentil crops. Good control with these concentrations has been obtained in 5 out of the 6 years during which the fungus was field tested in Saskatchewan and Manitoba.

In greenhouse and controlled environment tests, all growth stages of round-leaved mallow were susceptible to the pathogen. A minimum dew period of 20 h at 20–25°C and postinoculative air temperatures below 30°C were required to achieve satisfactory control of round-leaved mallow. Under field conditions, moisture and temperature following inoculation were the most important factors responsible for successful control. In Saskatchewan, normal dew conditions are not sufficient to obtain good infection, unless showers occur within 48 h of application. Once infection has taken place, development of the disease is not as dependent on moisture, although to obtain secondary infections moisture is critical. Early application coupled with rapid disease development increased wheat and lentil yields significantly.

Application for registration as a biological herbicide has been submitted under the trade name of BioMal, by Philom Bios, a biotechnology firm. If successful, it will be the first biological herbicide developed and registered in Canada.

WEED ECOLOGY AND PHYSIOLOGY

Wild oats

Seeds of several genetic lines of wild oats were induced to germinate on the plant by experimental treatments designed to maximize the availability of water. In nondormant lines, germination increased with the degree of maturity and varied between 70 and 80% on both excised and attached panicles treated at 10 and 5 days after anthesis, respectively. Germination was inversely related to the degree of dormancy and was significantly lower on intact plants than on excised panicles supplied with water through the cut end of the rachis. Measurements suggest that this difference may be due to the transpiration-induced negative water potential in the stem of the intact plant, which may inhibit embryo growth and thus prevent viviparous germination.

To determine correlation between seed-borne fungi and low seed viability, the fungi in seeds of seven lines of wild oats were examined. *Alternaria alternata* and *Cladosporium herbarum*, of which the latter was nonpathogenic and the former weakly pathogenic on wild oat seedlings, were predominant. *Drechslera avenacea*, *Cochliobulus sativus*, and *Fusarium* spp., frequently isolated, were pathogenic on wild oats. Only *D. avenacea* was host-specific to wild and cultivated oats. *C. sativus* and *Fusarium* spp. were equally or more pathogenic on seedlings of wheat, barley, oats, and rye than on seedlings of wild oats. *D. avenacea* occurred on a significantly higher percentage of seeds of AN 51 and AN 474 than the other lines. However, there was no relationship between low seed viability and fungi present.

Ditch-grass

Seeds of ditch-grass (*Paspalum distichum* L.) incubated at optimum temperatures between 28 and 35°C germinated 14 and 40% in darkness and with 16-h day-length, respectively. After-ripening was accelerated by dry storage of the seeds at 50°C, and germination was stimulated by immersing dry seeds in oxidants and a water rinse. Sulfuric acid was the most effective, followed by sodium hypochlorite and hydrogen peroxide, with the latter being effective only in the presence of light. Seed dormancy in ditch-grass is imposed mainly by seed coverings, including hull and seed coat membranes.

The rate of sprouting, rooting, and early growth of both single-node stem and rhizome segments of ditch-grass increased as incubation temperatures increased to about 30°C and then declined at 40°C. Generally, sprouting and rooting of shoot segments were faster than in rhizome segments. Single-node shoot segments sprouted faster in 16-h day-length than in the dark. Rooting was better in the dark at 10°C, unaffected by light at 22 and 28°C, and faster in the light at 35 and 40°C. Sprouting, rooting, and early growth were enhanced by gibberellin A_3, kinetin, and indole-3-acetic acid. Shoots collected at various times differ in sprouting and rooting responses. Varying responses to temperature may provide a survival mechanism for this weed.

Role of water in plant development

In the study of plants it is usual to make a distinction between growth and development. Although it is generally recognized that growth is most frequently limited and thus controlled by the availability of water, studies on plant development over the past 50 years have been concerned mainly with the role of auxin (IAA) and other hormonal factors. Yet it is evident that many developmental phenomena are, in fact, expressions of either the inhibition or promotion of growth or of differences in the relative growth rates of various organs or tissues of the plant. It might thus be expected that since water is so important as a limiting factor in the control of growth and metabolic activity, it will also play a major role in the regulation of many aspects of plant development.

The validity of this concept has been tested in various studies on weed physiology conducted at Regina during the past few years and has received considerable experimental support. An investigation of the mechanism of seed dormancy, a phenomenon frequently attributed to the influence of specific inhibiting substances, has provided convincing evidence that in wild oats, dormancy is controlled by factors that prevent the uptake of water by the embryo in the amount required to induce germination. Studies on the correlative inhibition of bud growth, which has long been regarded as a classical example of hormonal control, have shown for a wide range of perennial weeds that conditions and experimental treatments designed to maximize the water status of the plant can release the buds on the roots and rhizomes from inhibition.

Control of scentless chamomile

In a noncropland area that was being invaded with bluegrass and bromegrass, the vegetative growth of scentless chamomile was controlled following an application of picloram (0.3 kg/ha), picloram + 2,4-D (0.3 + 1.2 kg/ha), chlorsulfuron (0.06 kg/ha) + Agsurf 0.1%, and metsulfuron methyl (0.06 kg/ha) + Agsurf 0.1%. Plants that escaped herbicide treatment did not set seed. In the year following treatment, scentless chamomile was not found in the areas treated with herbicide or in the check plots. A combination of severe competition from the invading bluegrass and bromegrass, drought, and grasshoppers prevented the establishment of the weed.

Metsulfuron methyl (6 g/ha) + 0.1% Agsurf, chlorsulfuron (22.5 g/ha) + Agsurf 0.1%, and bromoxynil (350 g/ha) controlled scentless chamomile in HY320 spring wheat. Chemical control was assisted by spring tillage, which controlled plants of annual scentless chamomile in the winter, before the wheat was seeded. Seed set did not occur on scentless chamomile plants that escaped treatment.

1986 Saskatchewan weed survey

A comparison of weed communities, using data collected during the 4-year survey in Saskatchewan, indicated that the associations of weed species were more or less independent of the crop and were determined more by soil or the associated climate. The 40 most common species were divided into three groups by the analysis. The first group contained five common species found throughout the province. The second group (13 species) was associated with Brown and Dark Brown Chernozemic soils, and the third group (23 species) was associated with the Black and Dark Gray Chernozemic and Gray Luvisolic soils in the province.

Results from the 1986 Saskatchewan weed survey in cereal and oilseed crops indicated that no major shifts in weed species composition had occurred since the previous surveys (1976–1979), but that there had been an overall decrease in the frequency and density of the weed populations. The annual grasses wild oats and green foxtail were still the two most abundant weeds, and wild buckwheat and stinkweed remained the two most commonly occurring broad-leaved species.

Control of Canada thistle

Canada thistle plants require a 14–16 h photoperiod to induce them to elongate under Canadian prairie conditions. Plants emerging in spring will bolt, produce shoots, and set seed; plants that emerge in August remain as low-growing rosettes. Complete removal of top growth by cultivation of summerfallow during the last week of July results in large, low-growing rosettes of Canada thistle in mid August.

In field experiments, half the plots received summerfallow tillage in spring; Canada thistle plants were then allowed to grow to the bud stage, and herbicides were applied at the end of July. The remainder received normal summerfallow tillage until the last week of July. Canada thistle regrowth remained as low-growing rosettes. Herbicides were applied in the last week of August. Canada thistle shoots were counted in July of the second season. Plots treated with dicamba at 0.6 kg/ha applied in the August rosette stage had 88% fewer shoots than plots treated with dicamba at 1.2 kg/ha applied at the bud stage of the Canada thistle.

Long-term effect of 2,4-D application on weeds

At Indian Head, Sask., wheat plots have been sprayed annually with 2,4-D since 1947. The treatments since 1969 have consisted of herbicide application rates of 0.42 and 1.12 kg/ha. For all weed species that came up in these plots, plant number and size decreased with emergence date, with only a few small plants emerging late in the season. Over the long term, 2,4-D use significantly reduced the number of plants of susceptible species, but it did not eliminate them. A reduced number of susceptible plants enabled the number of plants of highly tolerant species to increase. Even in plots treated with high rates of 2,4-D, plants of the susceptible species (lamb's-quarters and stinkweed) were still as abundant as those of any other species group. The general effect of 2,4-D in treated versus untreated plots was to reduce the difference in performance of susceptible and tolerant species, resulting in changes in quantitative aspects of community structure. No new major species became established since 1947 as a result of 2,4-D application.

Downy brome

During the first weed survey of annual crop fields infested with downy brome, the kind and number of weeds in 35 fields were identified according to standardized weed survey procedures. Downy brome density averaged 213 plants per square metre, and associated weeds were Japanese brome, flixweed, green foxtail, and wild buckwheat. Japanese brome was found in five fields and was less abundant than downy brome in the area surveyed. A large number of downy brome seeds (50 000 seeds per square metre) were extracted from soil samples.

HERBICIDE BEHAVIOR IN THE ENVIRONMENT

Herbicide persistence and degradation in soils

Field plots at the Indian Head Experimental Farm have been receiving annual applications of ester and amine formulations of 2,4-D since 1947, and amine salts of 4-chloro-2-methylphenoxyacetic acid (MCPA) since 1953. In 1987, after 40 successive treatments of 2,4-D and 34 annual applications of MCPA, samples of all treated plots were taken from soil depths of 0–15 cm and 15–30 cm. Analysis of these samples revealed that amounts of 2,4-D or MCPA present in the soil were equivalent to less than 10 g/ha. This finding confirms that the repeated spring treatments of these chemicals will not be carried over in the soil to cause subsequent crop damage.

The fate of the experimental herbicide glufosinate-ammonium was investigated in three soil types at 85% of field capacity at 10 and 20°C. Breakdown was rapid, with half-life values of less than 10 days. Thus, glufosinate-ammonium is unlikely to be carried over in the soil under field conditions to the next crop year.

Minor use program

A request was received for the registration of the use of maleic hydrazide on parsnip to control sprouting during storage. The maleic hydrazide, at 3.0 kg/ha, was to be applied 4–8 weeks before the parsnips would normally be harvested and when the parsnip tops were still in good condition. A high pressure liquid chromatography (HPLC) analytical method was developed to determine maleic hydrazide residues in parsnip for which recoveries were in the order of 90% at the fortification level of 10 µg/kg. The method was used to determine maleic hydrazide residues in treated parsnip from three locations in Canada – Manitoba, Quebec, and Nova Scotia. Maleic hydrazide residues in the mature parsnip varied from 2 mg/kg (Quebec) to 16 mg/kg (Manitoba). Residues of this order of magnitude are required to effectively inhibit sprouting in other stored crops such as onion and potato.

Airborne residues of triallate and trifluralin in Saskatchewan

Airborne residues of triallate are present in both the southern and central regions of the province, indicating its general use in both agricultural areas. Significant airborne residues of trifluralin were present only at Melfort, indicating its general use in that area only. In addition, in spite of the prevailing northwesterly wind direction in the province, little or no trifluralin was detected at the southern site at Regina. Airborne herbicide residues were highest during and following their application, provided soil moisture conditions were conducive to vapor activity, after which the residues declined to low levels, with detectable losses corresponding to rainfall. When soil moisture conditions were dry during and following the application period, airborne residues corresponded to rainfall over the remaining growing season. However, airborne concentrations did not reach the maximums observed under moist application periods and years. Thus, increased carry-over of both of these herbicides can be expected in dry years. Vapor transport is a major route for the dissipation of these herbicides from the treated areas, with soil water as the limiting factor.

Fate of trifluralin and triallate applied as a mixture to a wheat field

Dissipation of triallate and trifluralin in air and soil was measured following their application as a preemergence treatment to a wheat field. Drift losses during application and incorporation were less than 1% of the amounts applied. Air samples, collected at six heights (ranging from 30 to 200 cm above the soil surface initially and then above the crop canopy following emergence during the 67 days after application) showed distinct gradients of each herbicide in the air, with the highest concentrations in samples closest to the ground. The highest flux rates for triallate and trifluralin were 4 and 3 g/ha per hour during the 4- to 6-h period after application, when the concentrations at 30 cm were 2500 and 1700 ng/m^3, respectively. Fluxes of both herbicides decreased with time, but were dependent mainly on soil moisture conditions. The total vapor losses for the 67 day sampling period were 17.6 triallate and 23.7% trifluralin. About half these losses were in the 1st week.

Application technology

New and conventional field sprayer systems are being evaluated for weed control at recommended and reduced herbicide rates and at various spray volumes using a large-scale field plot design. Less than recommended rates of diclofop methyl were ineffective in controlling oats, regardless of the type of sprayer used. Low application volumes reduced the performance of the recommended rate of diclofop methyl on oats, whereas performance using the recommended volume (100 L/ha) or 50 L/ha was better, with little difference between the two higher volumes. Performance of 2,4-D on oriental mustard using reduced herbicide rates was variable, with better control in 1987 than in 1986 at equivalent rates. There was little or no difference in the type of sprayer used. Reducing spray volume did not affect performance of 2,4-D when applied, with active ingredient (a.i.), to mustard at 140 g/ha. All sprayers tested performed equally well.

AGRONOMY

Winter wheat

The controversial use of 2,4-D for fall control of winter annual weeds in winter wheat is recommended in the Canadian prairies but not in other areas that produce winter wheat. Field research was conducted for 2 years at several locations using 2,4-D, MCPA, dicamba, dicamba plus 2,4-D, bromoxynil, bromoxynil plus MCPA, chlorsulfuron, and clopyralid applied in the fall and spring. Recommended and double-recommended rates were tested to establish the existence of a safety margin for crop tolerance. Norstar winter wheat was tolerant of fall application of all herbicides when applied at recommended rates. However, grain yield was reduced at the double rate with 2,4-D, MCPA, bromoxynil, bromoxynil plus MCPA, and clopyralid in some station-years. Norstar was tolerant of spring applications of all herbicides except MCPA and clopyralid in several station-years. Herbicides tested show promise for use in winter wheat production. Caution is warranted for spring application of MCPA and clopyralid.

Intensive cereal management

The feasibility of adopting European intensive cereal management principles for spring and winter wheat production in southeastern Saskatchewan was evaluated. The maximum economic yield corresponded fairly well to nitrogen levels recommended by the Saskatchewan Soil Testing Laboratory. In the case of winter wheat, the recommended nitrogen levels tended to be lower than levels where maximum economic yield was reached. There were no benefits gained by split applications of nitrogen. The benefits of fall banding over early spring broadcast of nitrogen were marginal.

The use of the fungicide propiconazole gave some positive results in both years and for both spring and winter wheat. Significant increases in 1000 kernel weight and yield were observed in both years. In some cases, the use of the fungicide gave economic benefits, but generally the yield increases were not enough to cover the cost of the treatment. However, the findings do indicate that disease pressure and economic losses may be greater than expected.

In both years lodging of the crop was not a problem, and consequently the use of plant growth regulators will have very limited application. If there is a problem, it can easily be avoided with the development of semidwarf cultivars.

SEED INCREASE AND DISTRIBUTION

In 1987 Agriculture Canada released to the SeCan Association seed (from winter seed increases in New Zealand and California) of the new cultivars Albany barley (400 kg), Capital oats (1611 kg), Orion fababeans (75 kg), Fleet meadowbrome (100 kg), Wildcat wheat (1301 kg), Bluesky wheat (1259 kg), Virden barley (150 kg), and Laura wheat (15 100 kg). There were 115 kg of Scimitar mustard released through the provincial stock seed committees to the Mustard Association.

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INTRODUCTION

This report covers the results of work completed in 1987 at the Saskatoon Research Station and at the Scott Experimental Farm, 160 km west of Saskatoon. Four research programs are conducted. These programs include multidisciplinary research on breeding, agronomy, and control of diseases, weeds, and insects on oilseed, forage, and cereal crops. We have the major responsibility in the Research Branch for research on rapeseed–canola and mustard. Saskatoon, along with the Lethbridge and Kamloops research stations, is an integral part of the branch's research program on development of bloat-safe alfalfa. We also have a major responsibility for the development of forage grasses for the northern prairies. The cereal program is concerned mainly with reducing losses from common root rot in wheat and barley and with the breeding of utility wheats. The integrated pest management program deals with the development of control systems for problem insects (i.e., grasshoppers, wireworms, wheat midge, and black flies) that are not specifically restricted to any one commodity. A major objective in the program is to minimize our dependence on insecticides for the control of these pests.

Reports and reprints of publications can be obtained from the Saskatoon Research Station, Research Branch, Agriculture Canada, 107 Science Crescent, Saskatoon, Sask., S7N 0X2; Tel.(306)975-7014.

J.R. Hay
Director

CEREALS

Diseases

Biological control of common root rot. Research is in progress for detecting microorganisms that are antagonistic to *Bipolaris sorokiniana* (Sacc. in Sorok.) Shoem., the fungus causing common root rot of spring wheat and spring barley in the Canadian prairies. *Chalara heteroderae* Carris & Glawe was found in soil from 12 locations in Saskatchewan. The average number of colony-forming units per gram of soil was 0.8, with a range from 0 to 4. There was some seasonal variation, with high numbers occurring in early July. *C. heteroderae* fed on the hyphae but not on the spores of several fungi. Common root rot symptoms were reduced by 50% in barley and by 10% in wheat when spores of the antagonist and spores of the pathogen were inoculated on plant coleotiles. In the field, treating barley or wheat seed with *C. heteroderae* did not reduce disease symptoms of common root rot. Since application other than by seed treatment is impractical, it appears that *C. heteroderae*, although of interest in soil ecology, is not a suitable biological control agent.

Plant stress and common root rot. Common root rot symptoms were more severe when wheat and barley plants were flooded for 72 h at the two- or four-leaf growth stages than when flooded for only 36 h. Although in both cases the disease was more severe on flooded than on unflooded plants, there was little difference between flooding at the two- and four-leaf growth stages.

In greenhouse tests, wheat and barley plants with mechanically damaged foliage developed more severe disease symptoms than did undamaged plants. In field studies, damaged and undamaged plants had similar levels of common root rot. The results of the above studies support the theory that common root rot is more severe when wheat and barley plants are under stress.

Leaf temperature and common root rot. In field studies, leaf temperature measurements made with an infrared thermometer were not correlated with disease ratings for common root rot in spring wheat. Only 2 of 47 comparisons in spring barley were positively correlated. Significant differences for common root rot occurred among cultivars of both wheat and barley, but leaf temperatures did not differ significantly. Thus, these results indicate that leaf temperature is not a reliable method for identifying wheat and barley plants infected with common root rot.

Common root rot disease progression. The progression of common root rot lesions on subcrown internodes of Neepawa wheat and Bonanza barley plants inoculated 14, 26, 38, and 50 days after seeding was measured in growth chamber tests. Both in wheat and barley, lesion development was more rapid in older plants than in younger ones. Variables such as mean daily rates of linear progression of lesions, disease ratings, and proportion of plants becoming severely diseased were higher in older than in younger plants.

Agronomic practices and common root rot. The effects of depth of seeding and plant density on common root rot in spring wheat were investigated in field tests. Generally, the disease intensity increased with depth of seeding. The effect was evident at various stages of plant development. Loss in yield did not closely parallel the increase in disease symptoms with depth. *Cochliobolus sativus* was the dominant pathogen and *Fusarium* spp. were minor ones. The relative frequency of their occurrence appeared to be unaffected by depth of seeding. Plant density had little influence on disease. A significant increase in incidence of diseased plants with increasing density occurred in only 2 of 12 tests, and differences in disease intensity were not significant in any test. Yield per plant increased markedly as density diminished, but loss in yield from the disease seemed unaffected by plant density.

Agronomy

Harvest dates and barley yield and quality. Three barley cultivars, Scout (a hull-less cultivar), Betzes, and Harrington, were harvested at a kernel moisture content (KMC) ranging from 12 to 55% at Saskatoon in 1983 and 1984. The traditional swathing–air drying–threshing method and the straight combining–artificial drying method were investigated. Generally, all cultivars showed little or no improvement in yield, 1000-kernel weight, test weight, proximate analysis, and malting properties as the KMC decreased from 40 to about 15%. Harvesting above a KMC of 40% caused yield losses ranging from about 21 to 35% and deterioration of most other properties. In 1983 straight (direct) combining generally resulted in yields averaging 10–15% higher than the traditional swathing method, but in 1984 the effect of the harvesting methods was reversed. The swathing method usually produced superior malting quality, but when harvested above a KMC of 40%, such barley would be suitable only for feed.

OILSEEDS

Agronomy

Effects of volunteer Brassica plants on crop growth. Possible deleterious effects of volunteer rapeseed or mustard on subsequently seeded barley, oats, flax, and rapeseed were examined by incorporating rapeseed or mustard herbage in amounts that might be produced in the fall by postharvest volunteer germination. The residual *Brassica* herbage reduced stand establishment and seed yield of the subsequently seeded oilseeds to a greater extent than that of the cereals. Among the cereals, barley was the most affected, while oats did not show significant reductions in stand or yield. Incorporation of straw and chaff of rapeseed in amounts that might be deposited at harvest in some instances resulted in reduced plant stands but did not show deleterious effects on seed yield. It is suggested that a cereal, preferably oats, follow rapeseed or mustard in the crop rotation to minimize losses from the deleterious effects of rapeseed residues.

Sulfur deficiency. Yields of rapeseed–canola frequently are low on sandy soils in northern Saskatchewan. On Loon River and Waitville loam (Luvisolic) soils of northwestern Saskatchewan, seed yield was increased significantly with the application of nitrogen (1.00 t/ha) and sulfur (1.06 t/ha). Sulfur application also increased oil content of the harvested seed. On very low-sulfur soils, without sulfur fertilizer, the seed glucosinolate content was abnormally low. Sulfur application increased glucosinolate content to normal levels. At sites where a sulfur response was obtained, grain protein levels were also increased. High rates of nitrogen tended to increase grain protein content but decreased oil content. Where sulfur was applied with nitrogen on deficient soils, oil content was higher than when only nitrogen was applied. Application of boron increased grain yield of rapeseed–canola in some instances when sulfur was also applied. The yield response to sulfur was significantly related to soluble sulfur levels in the soil.

These findings indicate that the problem of poor seed set and low yields of rapeseed–canola on the low-organic-matter Gray soils of Saskatchewan can be corrected by applying an adequate level of sulfur fertilizer in combination with other required nutrients.

Diseases

Root rot. Seedling and adult canola plants with symptoms of root rot were collected from commercial canola fields across Saskatchewan. *Rhizoctonia solani* Kühn, *Fusarium* spp., *Pythium* spp., and *Alternaria* spp. constituted 31, 21, 10, and 13%, respectively, of the fungal taxa isolated from seedlings, and 16, 37, 7, and 13%, respectively, of those from adult plants. Representatives of seven other genera of fungi were isolated in lower frequencies. Seventeen of 69 soil samples yielded *R. solani* at inoculum densities of one to 16 viable propagules per 100 g of soil. Isolates of *R. solani* from soil were assigned to anastomosis groups (AG) 2-1, AG2-2, AG3, AG4, and AG5, with frequencies of 36, 6, 4, 53, and 2%, respectively. Isolates from seedlings were either AG2-1 (94%) or AG4 (6%). Adult plants yielded AG2-1, AG2-2, and AG4, with frequencies of 69, 2, and 29%, respectively. This suggests some specificity of AGs in infecting canola plants. Most isolates of *R. solani* were pathogenic to canola seeds or seedlings. Isolates of the same AG showed a wide range of virulence, but in general, isolates of AG2-1 were more virulent than isolates of AG2-2 and AG4. Isolates from soil were less virulent than isolates from plants. Isolates of AG3 and AG5 were not pathogenic to canola seedlings.

Brown girdling root rot. *Rhizoctonia solani* Kühn, *Pythium ultimum* Trow, and eight species of *Fusarium* were isolated from the roots of diseased canola plants collected from the Peace River region of Alberta and from canola plants grown in the greenhouse in soil collected from the same region. About 95% of the isolates of *R. solani* were assigned to AG2-1, and all were highly virulent to canola seedlings in pathogenicity tests. Diseased plants typically had brown, sunken lesions often girdling the tap root, with few or no lateral roots present. The isolates of *P. ultimum* were less virulent; diseased taproots were shrunken, gray-black in color, and had no lateral roots. All isolates of *Fusarium* spp. were nonvirulent under the conditions of these tests. In additional tests using one isolate each of *R. solani* AG2-1 and AG4, canola plants were found to be susceptible to infection at all plant growth stages, but the most severe attack was on seedlings with the isolate of AG2-1. In all tests, plants infected with *R. solani* AG2-1 and AG4 had symptoms that were similar to those of the brown girdling root rot disease that occurs in the Peace River region.

Fungicidal control of white rust. The systemic fungicide metalaxyl was active against *Albugo candida* (Pers. ex Lev.) Ktze. race 7, the cause of white rust and staghead in *Brassica campestris* 'Torch'. Treating the seed with metalaxyl at 5.0 g/kg controlled foliar infection in the growth chamber up to the six-leaf stage. When sprayed on the plants up to 4 days after inoculation, metalaxyl reduced foliar infection by at least 95%. The effective concentrations for 50 and 95% control were in the range of 7.5–20.0 µg/mL and 57.0–91.0 µg/mL, respectively. Protection was effective for 6 days at a 95% control level of between 58 and 67 µg/mL. Foliar infection was also controlled when metalaxyl was applied as a soil drench but phytotoxicity was evident. Foliar spray applications at 2.0 kg/ha or higher reduced foliar infections in 3 years of field studies. Foliar applications also reduced systemic or staghead infections when applied at growth stages 3.2 or 4.1.

Insects

Predators of flea beetles. Predation on adults of the crucifer flea beetle, *Phyllotreta cruciferae* (Goeze), by the northern fall field cricket, *Gryllus pennsylvanicus* Burmeister, was recorded in laboratory tests. Late-instar nymphs and adult crickets ate a substantial number of adult flea beetles in these tests, with one sixth-instar nymph eating 80 flea beetles in 2 days. However, examination of the fecal pellets of nymphal and adult crickets collected in the field from a mustard plot with a large flea beetle population indicated that only 18–28% of the crickets had fed on flea beetles and that no individual had eaten more than two flea beetles in a 24-h period. Thus, although showing up well in laboratory tests, the northern fall field cricket does not appear to be a predator of major importance in regulating natural flea beetle populations.

Insect pests of sunflowers. Twenty-four species of parasitic Hymenoptera obtained from three lepidopterous and two dipterous insects that attack maturing sunflower seed heads were collected in Saskatchewan and recorded. An illustrated key was prepared to assist in the identification of the adults of each parasite species. Biological notes were made on host relationships, and the known geographic distribution of each species was elucidated.

Biotechnology

Blackleg toxins. Toxic fungal metabolites produced in liquid culture by weakly and highly virulent isolates of the blackleg pathogen *Leptosphaeria maculans* (Desm.) Ces. & de Not. were assessed on cotyledons and germinating seeds. The phytotoxicity of filtrates was similar for various culture media but differed significantly between the two types of isolates. The filtrates from the highly virulent isolates were much more phytotoxic to cotyledons than were the filtrates from the weakly virulent isolates. The toxins appeared to be heat-sensitive and non-host-specific.

Culturing protoplasts. Various factors affecting the culture of *Brassica napus* and *B. juncea* mesophyll protoplasts were examined with the objective of developing suitable culture media for these species. The factors investigated included mineral salts, vitamins, sugars, growth regulators, and osmotic stabilizers. Improved protoplast culture medium formulations were developed for both species. Plant regeneration was obtained from protoplast-derived calli in both species.

Breeding

Outcrossing. Rape, *Brassica napus* L., and mustard, *B. juncea* Czern & Coss, are considered to be largely self-pollinating species, but varying rates of outcrossing have been reported in the literature for these two species. No experiments have been conducted previously under the environmental and weather conditions of western Canada to determine selfing–outcrossing rates in *B. napus* and *B. juncea*.

The average interplant outcrossing rate was 21.8% for rape and 18.7% for mustard in experiments at Saskatoon in 1982, 1983, and 1984. No differences among cultivars within each species were observed, but outcrossing rates for individual plants within cultivars varied greatly. This observation has implications for the methods used for the breeding of new cultivars in these two species and the type of cultivars to be developed.

Quality

Rapid preparation of oil and meal. In breeding for improved oil and meal quality in rapeseed–canola and mustard, a large number of oil and meal samples must be prepared rapidly and efficiently. An apparatus was designed and constructed that permits small samples (2 g of seed) to be ground to a fine powder in the presence of petroleum ether. The oil-solvent mixture in each grinding tube is extracted from the suspension using negative pressure and a multifilter adapter plate. The "oil-free" meal is washed with solvent and dried under a partial vacuum. The apparatus allows the processing of up to 240 samples in an 8-h working day. The samples thus prepared are suitable for analysis of total oil content, fatty acid composition, protein level, glucosinolate content, and other quality parameters.

Wild mustard in canola fed to pigs. Ammoniation of canola seed containing wild mustard seed as a contaminant resulted in reduction of glucosinolates in the canola seed but not of hydroxybenzyl glucosinolate in the wild mustard seed. Feeding diets containing 25% canola seed including 0, 3, 6, and 9% wild mustard seed to crossed barrows from 23 to 57 kg had no effect on average daily gain or on daily feed intake, but the feed-to-gain ratio was poorer when wild mustard was present. Barrows from 57 to 100 kg showed no effect of dietary level of wild mustard seed with respect to average daily gain or feed-to-gain ratio. However, with wild mustard seed at 7.2 and 10.8%, carcasses were leaner than with 0% wild mustard seed. Gilts (57–100 kg) fed diets containing 30% canola seed produced similar average daily gains when wild mustard seed was present as 0.2 and 10.5% of the canola component of the diet. However, gilts fed the diet that was high in wild mustard seed produced leaner carcasses.

Brassica carinata

Seed color. Ethiopian mustard, *Brassica carinata* A. Braun, is an important oilseed crop in Ethiopia, with significant potential for use in other *Brassica*-oilseed-producing countries. Strains of *B. carinata* produce seed with either brown or yellow seed coats. Yellow seeds were found to contain more oil and protein and less fiber than brown seeds. To facilitate efficient breeding of yellow-seeded *B. carinata*, the inheritance of this characteristic was investigated in crosses between the brown-seeded cultivar S-67 and two true-breeding yellow-seeded selections. Seed color of F_1 seed, borne on the brown- and yellow-seeded parents, indicated that there was complete maternal control of this trait and that seed color is under the control of nuclear rather than cytoplasmic genes.

F_1 plants produced yellow seed with a slight tinge of brown (light yellow-brown), indicating incomplete dominance (semidominance) of brown over yellow. The backcrosses of the F_1 to the brown-seeded parent segregated in a ratio of one brown to one light yellow-brown, indicating that seed color is controlled by two alleles at one locus. Segregation in the F_2 generation supported this hypothesis, with one-quarter of the plants being brown-seeded. Unfortunately, the low level of dominance and the variable expression of the allele for brown seed color in the heterozygous condition makes visual selection of homozygous true-breeding yellow-seeded segregates unreliable. Thus, extensive progeny testing will be required in a breeding program to develop a pure yellow-seeded cultivar.

FORAGES

Grasses

New cultivars. In 1987 Agriculture Canada registered Kirk crested wheatgrass, Fleet meadow bromegrass, and Paddock meadow bromegrass, all of which were developed at the Saskatoon Research Station. These cultivars will enlarge the array of grasses available to farmers in western Canada and should result in additional seed exports.

Crested wheatgrass is estimated to occupy 1 million ha in Canada and 3.2 million ha in the United States. The average annual seed production in Canada from 1980 to 1984 was 324 000 kg. The present cultivars, Summit and Nordan, *Agropyron desertorum*, are tetraploid with particular adaptation to dry soils, whereas Fairway and Parkway, *A. cristatum*, are diploid with adaptation to somewhat wetter conditions. The new cultivar, Kirk, has been classified as *A. cristatum* because of its spike characteristics, but it is tetraploid, with the height and vigor of Summit and Nordan. Its area of best adaptation has not been determined, but especially good performance has been seen at northern stations, i.e., Melfort, Sask., and Fort Vermilion, Alta. It represents a new type for North America. Hay yields of Kirk are 4% above previous cultivars, and seed yield is 10% higher. Regrowth is as good as that of Nordan.

[illegible] the first cultivars of this species to be developed in Canada. To date the only available cultivar of this grass has been Regar, released in the United States from a Turkish source. Regar is regarded as a valuable pasture grass on Black soils in central Alberta because of its remarkably quick regrowth. Unfortunately, Regar has poor seed yields, and so the price of seed is prohibitive. The seed yields of Fleet and Paddock are approximately 70% higher than those of Regar. It is anticipated that the annual seed production of Fleet and Paddock will reach 100 000 kg. Two cultivars of meadow bromegrass, rather than a single strain, were released in order to provide an opportunity to test the marketing advantage of an exclusive release (Paddock) to a single seed company as against a general release (Fleet) to several seed firms. All three releases are through the Secan Association.

Seed color of reed canarygrass. A yellow-seeded mutant of reed canarygrass, *Phalaris arundinacea* L., was crossed with normal black-seeded plants and F_2, and test-cross populations were observed for seed color. Disomic inheritance was postulated, with two recessive genes y_1 and y_2 being responsible for yellow seed color. Black-seeded plants were designated $Y_1Y_1Y_2Y_2$, although in two black-seeded plants one locus appeared heterozygous, thereby suggesting that the alleles for yellow seed may occur quite frequently in this species.

Productivity of grass species. Six Eurasian temperate zone grasses, one mixture of these, and three North American wheatgrasses were compared in mainly nonfertilized tests from 1974 to 1983 in Saskatchewan. Introduced grasses outyielded indigenous species at Saskatoon when cut once per season as hay in the following declining order of yield (kilograms per hectare): intermediate wheatgrass (3819), standard crested wheatgrass (2906), smooth bromegrass (2841), Russian wild ryegrass (2311), Fairway crested wheatgrass (2218), meadow bromegrass (2082), slender wheatgrass (2011), western wheatgrass (1919), and northern wheatgrass (1683). Much the same order of yield was observed when these grasses were clipped two or three times per season, although meadow bromegrass and western wheatgrass performed relatively better. Standard crested wheatgrass and northern wheatgrass performed relatively better at Scott than at Saskatoon. Slightly lower in vitro digestibility ratings were shown for native species than for introduced ones; this finding appeared to be due to the more rapid senescence of the former. Stands at Saskatoon were maintained for 10 years for all species except slender wheatgrass, which lasted 5 years. Weed control was best for meadow bromegrass and smooth bromegrass, and poorest for slender wheatgrass, northern wheatgrass, and Fairway crested wheatgrass. When fertilizer was applied to older stands the introduced species gave a greater response than did the indigenous species.

INTEGRATED PEST MANAGEMENT

Wheat midge

Infestation in northeastern Saskatchewan. Annual canarygrass and oats were found to be free of natural infestations of wheat midge, *Sitodiplosis mosellana* Géhin, in northeastern Saskatchewan. Six-row barley cultivars had low infestations, but triticale, rye, common wheat, and durum wheat had high levels of infestation. Differences among cultivars of susceptible species were frequently due to asynchrony of wheat midge oviposition with the stage of floret development.

Extraction of wheat midge cocoons from soil. Wheat midge, *Sitodiplosis mosellana* (Géhin), overwinters in the larval stage as a larval cocoon. Extraction methods were developed to remove cocoons from soil samples. The accuracy of extracting wheat midge cocoons and larvae from soil samples averaged 99 and 94% for a sieving method and a brine flotation method, respectively. The time required to process bulk soil samples containing wheat midge cocoons was almost twice as long by sieving as by flotation. The time required to process field-collected soil samples containing wheat midge cocoons was also significantly longer by sieving and was longer for a silty clay loam than for a very fine sandy loam. Extraction costs varied from $1.65 to $3.99 per sample unit, depending on method and soil type. It was concluded that sieve extraction was the best method for studies on population dynamics and that flotation extraction was the best method for distributional surveys and [illegible]

Wheat midge and wheat quality. Wheat midge damage can impart a serious loss of quality to Canadian hard red spring wheat. The extent of this deterioration in quality is highly variable and not well related to degree of visual midge damage. Midge-damaged hard red spring wheat exhibits very high protein content, reduced flour yield, dark flour color, increased flour ash, weak, sticky dough properties, low baking absorption and poor bread quality. Midge-damaged wheat contains normal levels of alpha-amylase and proteolytic enzymes. Severely damaged wheat exhibits inferior gluten protein quality, but the cause remains obscure. The poor baking quality of severely damaged wheat is associated with an unusually low sodium dodecyl sulfate (SDS) sedimentation volume. Samples with visual evidence of midge damage can be rapidly screened for quality defects on the basis of protein content and SDS-sedimentation volume. Aerial applications of dimethoate and chlorpyrifos to fields of midge-infested hard red spring wheat significantly reduced both visual midge damage and the extent of wheat-quality deterioration.

Biological control of grasshoppers

Persistence of Nosema locustae. *Nosema locustae* Canning is a parasite of grasshoppers and is a potential agent for biological control of grasshoppers. The survival of *N. locustae* in field soils and its persistence in resident grasshopper populations in Saskatchewan were assessed in a 3-year study. Low levels of *N. locustae* spores persist in soils, but none were found in vegetation from treated fields. Large numbers of spores were sometimes detected in soil, depending on the extent of infection in the resident grasshopper populations. Indigenous soil microorganisms appear to prey on *N. locustae* spores during spore decomposition. *N. locustae* infection in resident grasshoppers varied, depending on the viability of the spores applied, and the level was higher following repeated (3-year) applications. Low numbers of *N. locustae* spores persist in soil, but large populations probably will not acccumulate because of leaching and because of their interaction with soil microorganisms.

Effect of Nosema locustae on soil microbiota. Microbial activity and nutrient cycling were not adversely affected when *N. locustae* or the chemical insecticides carbofuran, delta- [illegible] The insecticides were applied to a [illegible] loam at the recommended field rates and at 10 times these rates in laboratory tests. Likewise, a mixture of *N. locustae* and dimethoate had no adverse effect on microbial activity.

Egg parasites. The incidence of the parasite *Scelio calopteni* Riley in eggs of grasshoppers, *Melanoplus bivittatus* (Say) and *M. sanguinipes* (Fabr.), in Saskatchewan was monitored during 1967–1980. There were peaks in the buildup of parasite populations, but they were not related to host density. Furthermore, changes in grasshopper population density were independent of percentage of parasitism. Thus, it was concluded that parasitism by *S. calopteni* does not play a significant role in the population dynamics of the two grasshopper species. The relationship between parasitism and wetness in August was highly significant for both grasshopper species and showed that the percentage of parasitism increased (but at a decreasing rate) up to a certain wetness and leveled off thereafter.

Grasshopper toxicology

Loss of cypermethrin. The residues from metered doses of cypermethrin were recovered from excised portions of grasshopper cuticle to determine losses by volatilization. Residues from similar doses were also recovered from cuticles of intact grasshoppers and from whole-body homogenates after rinsing the cuticle, to determine rates of absorption and losses from metabolism. Residues were recovered from male and female grasshoppers uninfected and infected with *Malameba locustae* (King & Taylor) 1 and 3 weeks after fledging. They were maintained at 15 or 30°C and sampled from each combination of factors at 4, 8, 16, 24, 30, and 48 h after treatment.

There was no measurable loss of cypermethrin by volatilization up to 72 h after application to excised portions of cuticle at either 15 or 30°C. In all combinations of factors, more cypermethrin was recovered externally from grasshoppers held at 15°C than from those held at 30°C and more from infected grasshoppers than those that were uninfected. Significantly more cypermethrin was also recovered externally from males than from females and more from infected 1-week-old grasshoppers than from those that were 3 weeks old. At 15°C, there was a gradual trend towards accumulation of cypermethrin internally, but at 30°C an initial trend towards accumulation was followed by one of decline. In general, residual cypermethrin recovered could be related to the [illegible], to a decreased sensitivity to cypermethrin in infected grasshoppers, and to an increased sensitivity in older grasshoppers.

Persistence of dimethoate. Sweetclover herbage was collected for chemical analysis 0.1 h and 1, 3, and 5 days after the application of dimethoate at 35, 70, 125, 250, and 500 g/ha. After 5 days, 20% or less of the original dimethoate residue was detected. Wheat foliage was collected for both chemical and biological analysis at 0.2, 2, 5, 12, 18, 24, 48, and 72 h after application of dimethoate at 420 g/ha. In the first 24 h after spraying, there was a 65–85% loss of dimethoate from wheat foliage. Mortality of second- and third-instar nymphs of *Melanoplus sanguinipes* (Fabr.) (caused by eating the sprayed wheat herbage) decreased from an average of 55 to 19% in the same period.

Persistence of deltamethrin and cypermethrin. Residues of cypermethrin and deltamethrin in wheat herbage and grain, and deltamethrin in sweetclover herbage, were determined. Residues on wheat foliage declined exponentially, from 3.74 ppm immediately after spraying to 0.20 ppm 27 days after spraying cypermethrin at 28 g/ha. No cypermethrin residues were detected in the grain. Residues of deltamethrin on wheat foliage declined exponentially, from 0.70 ppm immediately after spraying to 0.05 ppm 27 days after spraying deltamethrin at 6 g/ha. No deltamethrin residues were detected in the grain. Deltamethrin was applied to sweetclover at 3, 4, 5, 10, and 16 g/ha. Residues on the herbage declined exponentially, from 0.10, 0.16, 0.22, 0.40, and 0.70 ppm immediately after spraying to 0.02, 0.03, 0.04, 0.15, and 0.18 ppm 5 days after spraying, respectively.

Pyrethroid insecticides and brain monoamine levels. High-performance liquid chromatography with electrochemical detection was used to measure 5-hydroxytryptamine and dopamine levels in the cerebral ganglia of grasshoppers, *Melanoplus sanguinipes* (Fabr.), and cockroaches, *Periplaneta americana* L., exposed to pyrethroid insecticides. The synthetic pyrethroid deltamethrin caused an increase in dopamine concentration in both grasshoppers and cockroaches and in 5-hydroxytryptamine concentrations in cockroaches. When these increases were observed at low doses, uncoordinated movement rather than rapid prostration was observed. The pyrethroid permethrin had no effect on amine levels in the grasshopper. In addition, amine levels in the grasshopper appear to be dependent on the age of the adult, with higher levels found in older animals. The

5-hydroxytryptamine metabolites *N*-acetyl-5-hydroxytryptamine and 5-hydroxyindoleacetic acid were not detected.

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Research Station
Swift Current, Saskatchewan

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J. Waddington, B.Sc., M.Sc., Ph.D.	Pasture establishment and physiology

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Departure

G.B. Bacon, B.S.A. Transferred, June 1987	Information Officer

VISITING SCIENTISTS

P.D. Gupta, Ph.D.(Eng.) Senior Fellow Central Research Institute for Dryland Agriculture, India, April to October 1987	Machinery evaluation
Kazi Munwar Ali, B.Eng. Barani Agricultural Research and Development Project, Pakistan, April to October 1987	Agricultural machinery
Ignatio Romagosa, B.S.(Ag.Eng.), M.S. (Agron.), Ph.D. Assistant professor Agricultural School of the Polytechnic University of Catalonia, Spain, February to December 1987	Wheat physiology

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[1] On leave, 14 December 1987 to 23 September 1988.

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INTRODUCTION

The research program at Swift Current encompasses breeding, physiology, and agronomy of wheat (hard red spring, durum, and Canada prairie spring) and rye; breeding, agronomy, ruminant nutrition and pasture management of forage crops; engineering, hydrology, fertility, agrometeorology, economics, and soil chemistry of soil and water management; and turkey nutrition. Research programs are designed to solve production problems and to evaluate new opportunities that will enable Canadian farmers, especially those located in the semiarid Palliser Triangle, to maintain or improve their competitive position in domestic and foreign markets.

The research capability of the station improved in 1987 through the return of several staff members from assignments elsewhere. Drs. T.F. Townley-Smith (wheat breeding) and J.E. Knipfel (ruminant nutrition) returned from secondments to the Regina Research Station and Regional Headquarters, respectively. Mr. G.E. Parker, information officer, returned from a 2-year secondment to a Canadian International Development Agency (CIDA) project in Pakistan. Mr. R. Knox, plant pathologist, joined the professional staff in plant breeding programs. Messrs. P.G. Jefferson, S. Tessier, and A.J. Leyshon returned to the station from educational leave for work toward Ph.D. degrees in plant breeding, engineering, and soils, respectively.

Examples of significant new developments in research include evaluations of the economic and agronomic performance of various crop rotations in several soil–climatic regions, assessment of the effect of 2,4-D on soil quality, and assessment of water quality in southwest Saskatchewan irrigation projects. New studies were initiated in tillage, agronomy, soil management, crop physiology, and turkey nutrition. Collaborative arrangements that complement Station research programs have been established with the South West Forage Association, the Saskatchewan Research Council, and the Saskatchewan Turkey Producers' Marketing Board.

Two scientists received major awards in 1987 in recognition of their research accomplishments. Dr. T. Lawrence received an Honorary Life Membership in the Canadian Seed Growers' Association and became a Fellow of the Agricultural Institute of Canada. Dr. C.A. Campbell won the Western Co-Op Fertilizers Agronomy Merit Award.

This brief report contains highlights of recent findings of our research programs. More detailed results can be obtained from our annual *Research Hi-Lites*, from published papers, or by direct contact with the Research Station, Research Branch, Agriculture Canada, Box 1030, Swift Current, Saskatchewan, S9H 3X2; Tel. (306) 773-4621.

B.H. Sonntag
Director

CEREAL PRODUCTION AND UTILIZATION

Wheat

Selecting for kernel color. White kernel color in wheat (*Triticum aestivum* L.) is preferred for the principal foods made from wheat in some countries. In general, white-kerneled wheats have a shorter dormancy period than red-kerneled wheats and are therefore subject to greater levels of preharvest sprouting damage caused by wet weather. In many countries, kernel color serves as the basis for segregating grain into classes. Kernel coat color is controlled by up to three genes. A study was conducted to investigate the effectiveness of a sodium hydroxide solution (NaOH) to enhance kernel color and thereby to facilitate distinguishing between red-colored kernels and white ones in wheat populations segregating for kernel color. Six two-way crosses (with five of them made in reciprocal), a single backcross, and a three-way cross were made to produce populations segregating for kernel color. A 1-*M* NaOH solution with 0.1% surfactant was applied to kernels of parents, F_1, and to several segregating generations. Kernel color reaction to NaOH was under maternal inheritance. The intensity of kernel color reaction to NaOH tended to be related to the number of genes for kernel color.

Rye

Effect of grazing winter rye on grain yield. Four cultivars of winter rye were grown for 2 years at two locations and defoliated in four treatments (no defoliation, defoliation in the fall, spring defoliation, and both spring and fall) to simulate grazing effect and to determine the possible effects of grazing winter rye on the subsequent grain production. Defoliation treatments, cultivars, and locations resulted in significant effects on all parameters measured. Defoliation treatments affected the four cultivars in the same way. However, differences in the cold tolerance levels of the cultivars and variation in the environment led to significant interactions in the effects of defoliation treatment × location and cultivar × location for most characteristics.

Defoliation of winter rye in the fall reduced grain yield less than if done in the spring, whereas defoliation in both fall and spring resulted in even greater reductions in grain yield. The most cold-tolerant cultivars were affected less by defoliation than were the less cold-tolerant cultivars. Maturity of all cultivars was delayed by defoliation in the spring, but not in the fall, and could lead to severe ergot infection in some environments. Defoliation may be useful as a technique to screen for cold tolerance of rye.

Drought physiology

Night transpiration. Over the night, stomata of wheat leaves took several hours to reach their most closed position and began to open some hours before dawn. The pattern and amount of night transpiration was changed by current vapor pressure deficit (VPD) but not by VPD or transpiration during the previous day. Mean night transpiration per unit of VPD was unchanged by current VPD. Night transpiration of whole plants increased linearly with VPD, though genotypes differed significantly in amount. The most profligate genotype transpired at 50 g/m^2 of leaf per hour at a VPD of 30 mbar, which was twice the rate of the most thrifty wheat.

Three methods were used to estimate the proportion of night transpiration occurring through the stomata and the cuticle: comparisons of stressed and unstressed leaves, wilting patterns of detached leaves, and transpiration rates of detached leaves in abscissic acid solutions. The methods gave equivalent rankings of the genotypes and similar absolute values for the "cuticular component," which contributed from 13 to 50% of total night transpiration. It is concluded that transpiration could exceed 0.5 mm per night in unstressed crops, though this would be considerably reduced by selection of genotypes with both low cuticular and low stomatal transpiration.

Leaf water loss. Water loss at minimum stomatal aperture (residual transpiration) from plant surfaces accounts for a substantial proportion of total transpiration during periods of water stress and at night. Its reduction by genetic selection has been suggested as a desirable objective in water-limited environments. To identify possible genetic and environmental sources of variation in residual transpiration of wheat (*Triticum* spp.), the effects of glaucousness, epicuticular wax, leaf age, plant height, and growth environment were determined using excised leaves. Glaucousness reduced residual transpiration by an average of 10%. Differing levels of epicuticular wax and glaucousness in an isogenic pair of genotypes affected residual transpiration as well, the rate being 44% greater in the low wax, nonglaucous line than in the high wax, glaucous line. Residual transpiration rate of flag leaves of field-grown plants increased with leaf age, particularly during the first 7 days following ligule appearance. The rate of residual transpiration was greater in tall lines than in dwarf near-isogenic lines. Residual transpiration of leaves from plants grown in glasshouses was 44–66% lower than that of plants grown outdoors, which had a mean rate of 2.68×10^{-5} g H_2O cm^{-2} min^{-1}. Method of water application to glasshouse plants influenced residual transpiration rate. The rate for leaves of plants watered by spraying water onto the plant and the soil surface was 20% greater than that of leaves of plants watered on the soil surface only. It was concluded that the increase in residual transpiration rate with leaf age was due to duration of exposure to the rigors of the exterior environment; the absence of this in controlled environments results in lower rates of residual transpiration than in the field.

FORAGE PRODUCTION AND UTILIZATION

Fertilization of annual canarygrass

Annual canarygrass may be grown on previously cropped land if soil moisture is adequate and required fertilizer nutrients are provided. Nitrogen fertilizer applied at seeding had no effect on days from seeding to emergence, heading or maturity, or on 1000 seed weight. Nitrogen had a positive linear effect on nitrogen content and a negative linear effect on test weight in all 5 years. There were positive linear and quadratic effects of applied nitrogen on seed yields, suggesting a maximum yield in the range of 50–75 kg/ha. Nitrogen content of the caryopsis was increased with nitrogen fertilizer applied at seeding, but total amino acid concentrations in the hydrolyzed proteins were not affected. The amino acid profile of the caryopsis was similar to that of other cereals, and the nitrogen-to-protein factor was 5.5.

Weed control in annual canarygrass

Field studies were conducted in Saskatchewan to evaluate the effect of herbicides on annual canarygrass (*Phalaris canariensis* L.) and associated weeds. Bromoxynil applied with active ingredient (a.i.) at 0.35 kg/ha, tank mixes of bromoxynil at 0.28 kg/ha plus the ester of MCPA with a.i. at 0.28 kg/ha, linuron with a.i. at 0.28 kg/ha plus MCPA amine at 0.56 kg/ha, or propanil with a.i. at 1.0 kg/ha plus MCPA ester at 0.28 kg/ha resulted in annual canarygrass seed and dry-matter yields equal to the unsprayed check and excellent wild mustard and cow cockle control. Metribuzin with a.i. at 0.21 kg/ha plus MCPA amine at 0.56 kg/ha reduced the crop stand in 1 out of 5 years and seed yield in every year. Postemergence application of difenzoquat with a.i. at 0.84 kg/ha or flamprop with a.i. at 0.53 kg/ha, or preplant-incorporated triallate with a.i. at 1.40 kg/ha optimized wild oat control with seed yields. Diclofop with a.i. at 0.70 kg/ha severely damaged annual canarygrass in all years. Triallate, applied at 1.40 kg/ha preplant- or preemergence-incorporated, marginally reduced the crop stand and seed yield compared with the untreated controls in tolerance tests.

SOILS AND ENVIRONMENT

Fertilization and crop rotations in the Black soil zone of Saskatchewan

Results from 25 years of a long-term crop rotation study in the Black soil zone at Indian Head, Sask., show that area producers can increase soil productivity, reduce fertilizer input, and increase economic returns by including grass–legume forages and legume green manure crops in the rotations with wheat. The yields of unfertilized wheat grown on areas that had been cropped to legumes averaged 15–24% higher when grown on fallow and 33–71% higher when grown on stubble compared with those obtained in unfertilized rotations that included only wheat. The yields from these legume-containing rotations were often similar to or higher than those obtained from well-fertilized wheat only rotations, except when high rates of nitrogen and phosphorus fertilizers were applied. The yield benefits from inclusion of the legumes arise from their ability to fix nitrogen from the air, increase the level of active soil organic matter, and scavenge or recycle nutrients from lower soil depths because of their deep-rooting characteristics.

Economics of rotations in the Black soil zone

Fourteen crop rotations have been under study at Indian Head for 25 years. The best economic performance has been obtained from fertilized continuous wheat, fertilized fallow–wheat–wheat, unfertilized sweetclover green manure–wheat–wheat, and unfertilized fallow–wheat–wheat–legume hay–hay–hay. The fertilized monoculture wheat rotations are the most profitable when grain prices are high or the fertilizer cost is low. The legume-containing rotations are better when grain prices are low or fertilizer costs are high. Risk, capital investment for extra machinery, and increased labor and management requirements are factors that farmers consider when using rotations involving only wheat or wheat combined with some fallow periods.

Yield and economics of some crop rotations

Long-term crop rotation studies at Swift Current showed that in this very dry region, producers are obliged to include some summerfallow in their cropping program if they are to remain economically viable and reduce the risk of frequent crop failure. A 3-year fallow–wheat–wheat system was shown to be as profitable as or, often, more profitable than the 2-year fallow–wheat system commonly used in this region when wheat prices were between $130 and $275 per tonne. The risk of economic loss increased as the proportion of fallow in the rotation decreased.

Crop rotations and fertilization effect on moisture use and conservation

A long-term crop rotation study in the Brown soil zone of Saskatchewan shows that although the amount of water conserved by summerfallowing or in stubble cropping has not changed in the past 40 years, grain yield per unit of water used has risen quite markedly. This improvement in efficiency was credited to a combination of better wheat cultivars, greater use of fertilizer by producers, and more effective weed control resulting from improved herbicides and timeliness of operations.

Spring wheat yields and moisture use

In a long-term crop rotation study at Swift Current, not only quantity but, even more, the distribution of growing season precipitation was demonstrated to be the main determinant of yields obtained in this dryland area. In all cases, heading growth stage was very important, but when cropping stubble land, precipitation at seeding time was just as important, since it determined the density of the plant stand. A second important finding from this study was the establishment of a simple formula by which yield of spring wheat grown on fertilized stubble land can be related to the depth of moist soil at time of planting and the amount of rainfall in one growing season. It was shown that producers could use the formula, together with rainfall probability data for the Swift Current area, and an estimate of spring soil moisture to calculate the chances of obtaining a yield high enough to recover cash costs and total cropping costs.

Estimating straw yields, nitrogen and phosphorous content of wheat, and nitrogen mineralization

Data from a long-term crop rotation study at Swift Current were used to develop regression equations that estimate various parameters related to cereal crop production. These equations allow first approximations of straw yields, nitrogen and phosphorus removed from grain and straw, and the amount of nitrogen produced by a loam soil during a major portion of the summerfallow period. These calculated values can be used to estimate fertilizer requirements for crops and to determine whether there is sufficient crop residue to prevent soil erosion.

Long-term 2,4-D application to the soil

The chemical 2,4-D has been used extensively for control of broad-leaved weeds in western Canada for some 40 years. In response to concerns that continued long-term use might be harmful to the soil, a field experiment at Indian Head was evaluated for herbicide effects on microbial processes essential to soil fertility. In this experiment a fallow–wheat–wheat rotation was sprayed each spring, since 1947, with amine and ester forms of 2,4-D at two rates (with a.i. at 0.42 and 1.12 kg/ha). The top 2.5 cm of soil, as the prime site of herbicide deposition, was repeatedly sampled and analyzed for changes in microbial biomass, nutrient release, and enzyme activity. Any depressive and stimulatory 2,4-D effects detected were small and short-lived when compared with the effects of natural stresses such as drought, flooding, freezing, and thawing. Continual use of amines or esters of 2,4-D did not cause any interference with nutrient cycling in soil. Consequently, this popular herbicide does not pose any threat to the fertility of our soils or to their ecological well being. The conclusions drawn from this study should lessen public concerns about the possibility of permanent disturbance of biological processes in the soil through the use of biodegradable herbicides such as 2,4-D.

Boron toxicity

Based on a survey of water, soil, and plant quality carried out at 29 irrigation projects in Saskatchewan, boron concentration in irrigation water was concluded not to be a problem. There are a few locations where crops sensitive to boron could be affected. Salinity poses a greater threat to crop production, and boron toxicity was closely linked to the salinity problem. Procedures that will solve salinity problems will also solve boron toxicity problems. The boron adsorption characteristics of some soils were established, which will allow scientists to predict the potential problems in a cross section of Saskatchewan soils.

ENGINEERING

Irrigation

A long-term field experiment was established in 1973 to determine the effect on alfalfa production of various concentrations of monuron and simazine in irrigation water. The results indicated that repeat applications of water that contained herbicides did not lead to a continuous buildup of residue in the soil. The residue levels of herbicide increased in the early years after application, but they reached a state of equilibrium in 2 years for monuron and 4 years for simazine. In southwestern Saskatchewan, irrigation water containing either monuron or simazine at a rate of up to 100 µg/L did not show any permanent or harmful effects on the capacity of an alluvial clay soil to produce healthy alfalfa.

Repeated irrigation with herbicide-enriched water at a rate of 1000 µg/L resulted in accumulation of herbicide residues in plant tissues through root uptake and caused severe yield reductions. At this rate of application, the buildup of monuron residue in the soil had no effect on oats during the year following the final herbicide application, and the simazine residue in the soil reduced oat yields extensively during the 2 subsequent years under dryland farming. It is recommended that water containing monuron or simazine at a rate of more than 100 µg/L not be used for repeated irrigation.

Alternative fuel control parameters

In research conducted to determine allowable alternative fuel substitution parameters and to evaluate the use of spark ignition knock sensing technology, equations using engine speed, normalized fuel consumption, intake mass airflow, intake boost pressure, and rate of exhaust energy rejection were developed to predict engine torque and allowable secondary fueling level. The normalized fuel consumption equation was the best predictor of engine torque, but air consumption best reflected the maximum ethanol substitution limits. Two commercial combustion knock sensors were evaluated, with the Carter transducer showing the most promise.

The use of normalized fuel flow or exhaust energy loss equations as measures of engine load combined with the use of combustion knock as determined by the Carter transducer showed promise as control and feedback parameters for a dual-fuel control system. Further research in the dual-fuel area should employ combustion pressure sensing to detect the onset of combustion knock and misfire and, therefore, to determine the maximum allowable substitution levels of secondary fuels in a reliable manner.

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P.F. Mills, B.A.	Micrometeorology
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T.I. Szabo, B.A.E., M.Sc., Ph.D.	Apiculture

Experimental Farm, Fort Vermilion, Alta.

B. Siemens, B.S.A., M.Sc.	Superintendent; Forage crops
G.W. Clayton, B.S.A., M.Sc.	Crop production

Departure

H.G. Najda, B.A., B.Sc., M.P.M. Transferred 1 May 1987	Grass seed management

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[1] On secondment to Ottawa, February 1987–.

[2] On transfer of work to Davis, Calif., December 1987 to December 1988.

INTRODUCTION

The Beaverlodge Research Station and the Fort Vermilion Experimental Farm comprise the Northern Research Group. The Northern Research Group has the responsibility for research and technology transfer on agriculture in the northern half of Alberta and British Columbia – the Peace River Region – plus more limited work on behalf of the Yukon and Northwest Territories. The land resource entails over 2.2 million hectares of cultivated land and the region has an agriculture land resource for development for an additional 7 million hectares. The research is targeted to adapt crops and cropping management to the environment and soils of a northern climate lying largely north of the 53 N latitude. About 20% of the soils are acidic (below pH 6.0). Growing periods are 70–134 days (base -2.2°C). In part, the short growing season is compensated by extremely long days during May, June, July, and August with 2121 h of bright sunshine annually. The predominant crops are barley, canola, wheat, forage grasses, and legumes for seed and honey.

The staff of 50 conduct their work under 10 Research Branch objectives. In addition to federally funded projects, several of our clients participate in research partnerships. Farming for the Future, Alberta Research Council, and Western Grains Research Foundation are predominant partners. The Northern Research Group receives inputs into their research by formal and informal contacts with its clients, who range from individuals to organized commodity groups and agri-business. This allows the Northern Research Group to target its resources at regional needs and problems while serving the broader national objectives and strategies. The Northern Research Group also cooperates with Alberta Agriculture and B.C. Ministry of Agriculture and Fisheries and the universities of Alberta and Saskatchewan. A very successful cooperative venture with the University of Alberta in sponsoring a symposium on acid soil-plant interaction was held in the Peace River region, with over 120 participants from Canada, the United States, and several other countries.

During 1987 Mr. H. Najda resigned to take up a position with Alberta Agriculture. Dr. J.S. McKenzie was seconded to headquarters in Ottawa and is currently working with the Industrial Relations Office. Dr. T.P.S. Liu commenced a transfer of work to the University of California, Davis, to work on parasites of honey bees (Tracheal mite and Varroa mite). Dr. W.A. Rice returned from his secondment in Pakistan (Barani agricultural research and development project), and Dr. M. Arshad returned from his transfer of work with the Land Resource Research Centre, Ottawa. Dr. T.I. Szabo received the Order of Canada Award for his research in honey bee breeding and management. Dr. Szabo licensed the Alberta bee, which he bred with assistance from Farming for the Future.

The brief reports that follow give results of research in 1987. Detailed information can be obtained from the publications listed in the report or by correspondence with individual research scientists or the station director. The addresses are Research Station, Research Branch, Agriculture Canada, Box 29, Beaverlodge, Alta. T0H OC0, Tel. (403) 354-2212; and Experimental Farm, Research Branch, Agriculture Canada, Fort Vermilion, Alta. T0H 1N0, Tel. (403) 927-3253.

J.D. McElgunn
Director

APICULTURE

Management

Pollen trapping. Continuous pollen trapping from package bee colonies and its effects on brood and honey production were studied for 3 years (1983–1985) in the Peace River region of Alberta. An average of 9.4 kg of pollen was collected and there was little effect on sealed brood production compared to controls. Honey production was reduced by 20% on an average compared to controls, but it was significant only in one of the 3 years. The gross income from the trap treatment was 21% greater than for the control treatment. Pollen trapping in the Peace River region seems to offer beekeepers a chance to diversify and to increase their gross income.

SO_2 fumigation on combs. Between 1977 and 1983 the driedfruit moth, sometimes called the bumblebee wax moth, has increased from rare to common in Alberta and British Columbia. Its larvae may cause substantial damage to honey bee colonies and combs in western Canada, especially to combs that are in storage for more than 1 year. Sulfur dioxide (SO_2) gas produced in a closed room by the ignition of sulfur granules (in the form of commercial fertilizer) killed 100% of the imagines, pupae, and larvae in infested combs after 2–3 days of fumigation.

Mating distance. Mating nuclei were placed at 2-km intervals up to 20 km from a drone apiary. Some matings occurred at a distance of 20 km in 1984 and 12 km in 1985. Mating distance was significantly correlated with time (days) to the beginning of oviposition ($r = +0.723$ for 1984 and $r = +0.830$ for 1985). Mating distance and numbers of spermatozoa, and time to the beginning of oviposition and numbers of spermatozoa were significantly correlated in 1985 ($r = -0.676$ and $r = -0.591$, respectively) but not in 1984. In both years significant multiple correlations were found for distance, numbers of spermatozoa, and time to beginning of oviposition ($R = +0.747$ for 1984 and $+0.831$ for 1985).

Pathology

Nosema disease. Queen honey bees *Apis mellifera* and worker attendants, brought via air mail into western Canada, were examined for both *Nosema apis* and *Malpighamoeba mellificae* in each of 2 years. Seven of 53 queens examined were infected with *N. apis* only, four with *M. mellificae* only, and 13 with both. One hundred and eight of 406 workers examined were infected with *N. apis* only, 46 with *M. mellificae* only, and 95 with both.

Corpora allatal cells of healthy honey bees *Apis mellifera* had a nucleus with dispersed chromatin material, large mitochondria with a well-defined membrane in the cytoplasm, and axons between cells containing two kinds of neurosecretory granules. In cells of the corpora allata of *Nosema*-infected bees, the chromatin material in the nucleus was electron-dense and much more compact. Mitochondria were smaller, with well-defined membranes and electron-dense matrices. Neurosecretory granules were rarely observed in the axon.

Overwintering colonies were fed 200 mg of fumagillin in sugar syrup in the fall of 1985. The following spring, the average *Nosema apis* spore count was 15.53 million per bee. Sixty colonies were fed 42 mg of dry fumagillin in a 1:5 mixture of Fumidil B–icing sugar in two dosages over a 10-day period, while 68 colonies received no medication. Mean *Nosema* counts of the medicated colonies 1 week and 3 weeks after medicating were 4.05 ± 0.51 and 4.82 ± 0.59 million spores per bee, respectively, whereas colonies that were not medicated had 18.47 ± 0.82 and 18.09 ± 1.00 million spores per bee. This method of medicating is a simple and effective means of reducing *Nosema* levels in the spring.

Fine structure of chalkbrood sporocysts. The fine morphology of the sporocysts of *Ascosphaera apis* (Maassen ex Claussen) Olive & Spiltoir, an entomopathogenic fungus of the immature honey bee has been studied, using the scanning electron microscope. During the 3rd day of mycelial growth in the culture medium, numerous short, branched hyphae were formed. The tip of the branch-hypha gradually expanded to form immature sporocysts. The immature sporocysts contained a large number of globules of varying sizes. The walls of the immature sporocysts were finely wrinkled, becoming smooth as the sporocyst matured. Both exterior and interior surfaces of the sporocyst wall possessed numerous papillae. Some globules in the developing sporocyst began to form immature spores that aggregated to form spore balls. The fully formed spore balls were not enveloped by a membrane.

CEREALS

Barley

Jackson barley was in its 3rd year of commercial production in 1987. It was grown on 9% of the Peace River region barley hectarage, and 59 000 ha in all in Alberta and British Columbia. It is a partial replacement for Otal, in that it is only 2 days later in maturity, has stronger straw, and is about 6% higher in yield. Outside of the Peace River region its hectarage is mainly in the west-central and northern agricultural areas of Alberta, where it has provided an earlier-maturing alternative to some of the midseason feed barleys.

In barley breeding the main emphasis continues to be on the production of early-maturing, six-row, non-malting types, with backcrossing of earliness and scald resistance into some of the top western Canadian two-row malting selections.

Wheat

Two Canada Utility (CU) wheats were registered out of our wheat breeding program in 1987. They are Bluesky (PT325) and Wildcat (PT329). Both are earlier than the standard CU wheat, Glenlea. Wildcat, the earliest and similar in maturity to the Canada western red spring (CWRS) wheats, Neepawa and Katepwa, has higher protein levels and somewhat better CU quality than Glenlea, which may help attract more CU export markets.

In wheat breeding the two major emphases are on the production of early-maturing varieties for the Canada prairie spring and CWRS grades.

FORAGES

Viability of prepupae of leafcutting bees during extended storage

In the management of the alfalfa leafcutting bee, *Megachile rotundata* (Fabricius), diapausing prepupae are overwintered at 3–5°C for approximately 260 days before use for a current season's pollination. In this study, viability of diapausing prepupae was investigated at 28-day intervals between days 260 and 641 of storage. Substantial numbers of bees emerged from prepupae stored for up to 501 days; however, 50% of the sampled prepupae became nonviable after 417 days. About 95% of the emerging bees survived for at least 24 h. Survival of emergent adults did not depend on storage time or sex. Nevertheless, after emergence, the number of surviving males fell faster than females. This could partly be attributed to the sex ratio, but could possibly be a result of the greater body weight and perhaps a larger food reserve in female bees as compared with males. The early depletion of males is not necessarily detrimental to the pollinating efficiency of a colony. Previous studies have shown that females are the predominant pollinators and that the numbers of males dwindle quickly as females begin nesting.

The study demonstrated that a viable pollinating colony of alfalfa leafcutting bees can be obtained from cells that are stored up to 501 days at 5°C, even though mortality levels reach 50% after 417 days of storage. During this period, this pollinator could be used in greenhouses or in seed fields in the southern hemisphere.

Effect of row spacing on grass seed and hay production

The effect of row spacing on seed and hay yields of 11 perennial grass species, including crested wheatgrass (*Agropyron cristatum* L.), intermediate wheatgrass (*A. intermedium* (Host.) Beauv.), a northern biotype of bromegrass (*Bromus inermis* Leyss.), a southern biotype of bromegrass, Russian wildrye (*Elymus junceus* Fisch.), meadow fescue (*Festuca pratensis* Hudson), creeping red fescue (*F. rubra* var. *genuina* L.), chewings fescue (*F. rubra* var. *commutata* Gaud), reed canarygrass (*Phalaris arundinacea* L.), a turf-type timothy (*Pheum bertolonii* DC (*P. bulbosum* auct.)), and hexaploid timothy (*Phleum pratense* L.), was studied under a system with limited inputs of fertilizer and no weed control. The width of the row spacings ranged from 16 to 104 cm where seed yields were measured and from 27 to 93 cm where hay yields were measured. The seed yield of all grasses was greater at a row spacing of 16 cm than at row spacings of 60 cm or more. Hay yields of all grasses, averaged over four production years, were also greatest at narrow row spacings (27 cm). These yields decreased as row spacings increased to 49 through 93 cm. Row spacing had its greatest effect on hay yields during the first production year. After this period the effects of row spacing on hay yields were small.

ENVIRONMENT AND SOILS

Root distribution of and water uptake by barley

A field study was conducted in 1984 and 1985 to determine the spatial distribution with time of root length density of spring barley (*Hordeum vulgare* L.) growing in a Black Solod in northwestern Alberta. The weakly solonetzic Bnt horizon present in the solodic soil appeared not to inhibit root growth, and roots were present to 90 cm depth of soil. Drought in 1985 reduced root growth in general, and in particular in the surface soil (0–15 cm depth) between crop rows. Root growth in both years continued well after ear emergence and attained a maximum total length (14.5 and 9.5 km·m^{-2} in 1984 and 1985, respectively) some time into grain-filling. Water uptake rates of up to 1.3 cm^{3}·m^{-1}·d^{-1} were observed; this maximum rate was associated with younger roots in the 60–90 cm depth in 1984. Low availability of subsoil water in 1985, however, resulted in low root density and water uptake rates in the 60–90 cm depth. The weighted mean uptake rate for the entire root system was slightly more than 0.4 cm^{3}·m^{-1}·d^{-1} in 1984 and about half that in 1985.

Nutrient uptake by barley

A 2-year study with barley was conducted to provide data on uptake rates of N, P, K, and Mg and their variation as the growing season progressed. Two varieties were grown: Galt in 1984 and Otal in 1985. Inflow, i.e., uptake rate per unit root length, of plant nutrients, decreased with time. Inflow, or uptake rate was low in 1985 because of moisture deficiency, and grain yield (0.89 t·ha^{-1}) was severely depressed. The results of this study suggest that split application of nitrogen fertilizers may be feasible up to approximately 6 weeks after sowing if soil and weather conditions are suitable.

Lime–phosphate (P) interaction and alfalfa and barley growth

Alfalfa (*Medicago sativa* L. 'Peace') and barley (*Hordeum vulgare* L. 'Otal') were grown under greenhouse conditions on three moderately acid soils (pH 4.7–5.1). Calcium amendments consisted of adding $CaCO_3$ to achieve pH values of 6.0 and 6.7, or $CaSO_4$ (gypsum) equivalent in Ca to $CaCO_3$ to attain pH 6.7 and a check (nil Ca). Three P treatments were superimposed on each Ca treatment, i.e., P at 0, 30, and 60 mg·kg^{-1} soil. Dry matter yields of both alfalfa and barley were increased by $CaCO_3$ and not affected by $CaSO_4$. Phosphate increased yields although soil test results indicated adequate P. There was a strong Ca–P interaction. The yield increase due to $CaCO_3$ and P additions was greatest for the soil with the least amount of extractable P, and relatively small when the soils were limed from pH 6.0 to 6.7. Liming reduced aluminum (Al) concentration and increased P concentration in the soil solution.

Gypsum increased Al concentration and had variable effects on solution P concentration. Soil solution P concentration and soil pH accounted for 85% of the yield variations in barley.

Organic matter in crusted soils

Luvisols are the dominant soils in the Peace River region of northern Alberta. These soils are quite acidic, often low in organic matter, and weakly aggregated. They turn into flour-like powders during seedbed preparation. A heavy rainfall immediately after seeding leads to the formation of surface crusts that restrict seedling emergence of most arable crops.

Chemical and spectroscopic characteristics were determined on the organic matter in two Luvisolic soils. One of these, the Debolt soil, crusts only slightly, whereas the other, the Demmitt soil, exhibits severe crusting after heavy rainfalls. The Debolt top soil was found to be richer in total carbon (C), total nitrogen (N), carbohydrates, and proteinaceous materials than the Demmitt top soil. Humic acid extracted from the Debolt soil was more aliphatic and contained fewer carboxyl groups than did humic acid extracted from the Demmitt soil. The quality of the organic matter appears to play a role in soil crusting.

Root-temperature effects on nodulation

Axenically grown alfalfa (*Medicago sativa* L. 'Peace') was simultaneously inoculated with Canadian commercial *Rhizobium meliloti* strains NRG-185 and BALSAC. The plants were grown for 7 weeks in sealed units at five different root temperatures (8, 13, 17, 21, and 25°C) and at a relatively constant air temperature (24–30°C). Nodule occupancy by each strain was determined by enzyme-linked immunosorbent assay (ELISA). Nitrogenase activity, nodule fresh weight, and plant dry weight were also measured. The lowest root-temperature regime (8°C) resulted in substantially lower nodule numbers and weights and plant dry weights than the higher temperature regimes. Development of nitrogenase activity was completely inhibited at 8°C. The immunoassay of nodule-strain occupancy showed markedly different strain-nodulation responses to the various root-temperature regimes. At 8°C, 63% of nodules were occupied by both strains. Dual strain occupancy decreased from 63% to 2% with increasing root-growth temperature, whereas the proportion of nodules containing only strain NRG-185 increased from 9% to 75%. Nodules containing only strain BALSAC remained relatively constant at 25% from 8 to 21°C, decreasing slightly at 25°C. The results suggest that root-environment temperatures during the period of nodule formation may have major differential effects on the success of competing rhizobial strains. If this is so, then selection of *Rhizobium* strains with enhanced low-temperature nodulation capabilities should be possible.

Soil inoculants for alfalfa

Field experiments were conducted with alfalfa (*Medicago sativa* L. 'Peace') planted on a soil with pH 5.8. Granular inoculant was applied with the seed, below the seed, or beside the row, or liquid inoculant was applied beside the row. The inoculants were prepared with *Rhizobium meliloti* NRG-61, which had been selected for low-pH tolerance. Forage yield, nodule numbers and weight, and inoculant strain occupancy of nodules were measured. Granular inoculant applied with or below the seed resulted in greater than 87% of the nodules occupied by strain NRG-61 and increased nodule numbers and weight and forage yield when the moisture conditions for germination and plant establishment were favorable. Under moisture-limiting conditions the inoculant had little effect. The use of granular or liquid inoculant banded beside the row after crop establishment was not effective in improving nodulation nor in increasing forage yield.

Field calibration of liming responses.

Liming trials were conducted at 28 sites in the western Great Plains of Canada for barley, rape, red clover, and alfalfa. Yield increases from liming correlated with soil pH and Al but not with manganese (Mn). When all sites were included, yield increases from liming correlated closely (r = 0.86–0.94) with exchangeable Al, percentage of Al saturation, and 0.02 M $CaCl_2$–Al for barley, rape, and red clover, these responses having correlated less well (R = 0.56–0.72) with soil pH. Alfalfa yield responses gave low correlation with both pH and the Al measurements. When only the sites with soil pH 5 were used, the yield responses to lime of barley and rape still correlated better with the Al measurements than with pH, even though the correlations, in general, were much lower than when all sites were included. For the sites with soil pH 5, the correlations were highest for yield responses of barley and rape with 0.02 $CaCl_2$–Al. It is suggested that the use of toxic Al and Mn for routinely diagnosing the limiting factor by soil acidity could improve on the economy of liming.

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Research Station, Lacombe, Alberta

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D.D. Jones	Administrative Officer

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Departure

H. Doornenbal, B.S.A., M.S.A., Ph.D. Retired 4 December 1987	Physiology

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[1] On educational leave effective 19 August 1986.

INTRODUCTION

The Lacombe Research Station and the Soils and Crops Substation at Vegreville are responsible for regional agricultural research in the central Alberta parklands. Specifically, programs include soil reclamation and development of cropping practices for Solonetzic soils of east-central Alberta; breeding new, high-yielding, disease-resistant oat and hard red spring wheat (replacement for Park) varieties for domestic use and export; and developing soil fertility, soil management, and weed control and cropping systems for barley, oat, and canola production in the parklands. The station has regional responsibility for production and disease research of perennial forage crops; for developing and evaluating hay management systems that will improve the quality of stored forages; and for developing management systems and evaluating new forage species and plant growth regulators to extend the pasture season, all of which will be used by beef and dairy farmers to optimize milk and beef production per hectare. The Lacombe Research Station's mandate also includes research responsibility for regional and national programs in red meats, with integrated supporting programs in pork and beef production that include developing and evaluating different muscle types of meat animals; assessing the effect of nutrition, management, and environmental stressors on growth, performance, and subsequent carcass quality; and the technical research aspects of the beef cattle and swine record of performance (ROP) testing programs. The red meats research includes developing and evaluating new procedures and techniques for improving the effectiveness of national departmental beef and swine carcass grading programs. The research also involves work on the physical, chemical, microbiological, and sensory aspects of beef and pork quality in relation to preslaughter and postslaughter environmental conditions, processing systems, and carcass management, both at the meat-packing plant and at the retailer level, and with consideration given to cooking quality and other factors related to consumer acceptance of the final product.

This report summarizes the highlights of research completed in 1987. Further information on any of these research activities, reprints of publications listed in this report, and copies of previous reports may be obtained from the Research Station, Research Branch, Agriculture Canada, Bag 5000, Lacombe, Alta. T0C 1S0; Tel. (403) 782-3316.

D.E. Waldern
Director

RED MEATS AND BEEF PRODUCTION

Beef production

The effects of fasting and transportation on beef cattle: Acid–base–electrolyte balance and infrared heat loss. Transportation, mixing, and handling conditions to which cattle are subjected during marketing represent significant physical and phycological stressors. Collectively, these events create an economically costly situation, exemplified by such factors as dark–firm–dry (DFD) beef and excessive carcass weight loss, and present a challenge to the animal industry in terms of improving both animal welfare and meat quality. The intention in the present study, therefore, was to improve our understanding of the physiological adaptation or changes on animal experiences as a result of transportation, time off feed, and mixing prior to slaughter.

Fifty yearling, market weight Hereford steers and heifers were allocated to one of three treatments. Treatment one (T1, $N = 17$) animals were transported 3 km and slaughtered, following a 24-h fast. Treatment two (T2, $N = 17$) animals were mixed by sex, transported 320 km, and slaughtered after a 48-h fast. Treatment three (T3, $N = 16$) animals were transported as per T2 with an additional 320 km transport on day 2 (total fasting = 72 h) prior to slaughter. Compared to pretreatment measurements, blood bicarbonate, base excess, carbon dioxide, and hydrogen ion concentration were reduced ($P < 0.01$) for all animals when measured again immediately following preslaughter. In contrast, blood lactate was seen to increase ($P < 0.04$) compared to preslaughter values. Among treatments, T2 animals displayed higher ($P \leq 0.05$) bicarbonate, base excess, and standard bicarbonate values than animals in T1 or T3. The mean infrared body heat loss was reduced ($P \leq 0.01$) with increased fasting and transportation, which coincided with progressively darker meat color. These data suggest marketing stress can induce changes in the acid-base and thermodynamic status of an animal.

Swine

Infrared thermography in three lines of pigs with known genotypes for stress susceptibility in relation to pork quality. The present experiment was conducted as a preliminary study to determine whether infrared temperature differences in live pigs or the separated carcass halves of those pigs were related to meat quality traits. Twenty-five market weight pigs averaging 91.9 kg body weight and representing three genotypes were used in the study. The genotypes consisted of eight Lacombe breed (L), nine crossbreed (C), and eight halothane positive (H) animals. Infrared thermographs of the dorsal and lateral surfaces were taken on all animals immediately prior to stunning and again, of the split carcass halves, at 45 min post-stunning. Thermograph analysis demonstrated no differences in mean lateral temperatures among genotypes (C) in the live animal (26.8 ± 0.8 (SE) L; 26.6 ± 0.7 C; 25.7 ± 0.8 H) or in the inside carcass surface (23.9 ± 0.5 L; 22.8 ± 0.6 C; 23.6 ± 0.6 H). Furthermore, the correlation between infrared thermograph values and most meat quality traits for all genotypes was nonsignificant ($P > 0.05$). However, the halothane positive pigs did display a highly significant negative correlation between expressible juice (−0.87, $P \leq 0.01$) as well as percentage of drip loss (−0.75, $P \leq 0.5$) with mean live lateral surface temperature. This highly significant negative correlation of infrared thermography values with expressible juice and percentage of drip loss in the halothane positive pigs warrants further study, especially under conditions that would likely predispose pigs to a higher incidence of pale–soft–exudative meat quality.

Meat quality

The effect of shrouding on the appearance of spray-chilled beef carcasses. The shrouding of beef carcasses is a traditional process that improves the appearance of the cold carcass. This process is labor intensive and for this reason its use is being increasingly questioned, particularly when beef carcasses are processed in the original slaughter plant. Left and right carcass sides from 264 warm beef carcasses were alternately shrouded (Sh) or not shrouded (NSh) to investigate the influence of this practice on the appearance of the cold carcass. A higher frequency ($P < 0.001$) of sides with a white and smooth external covering of fat was found for the Sh compared to the NSh treatment. Sh sides had similar ($P > 0.05$) marbling scores, 24 h pH, loin eye area, and loin eye muscle color to NSh sides. Shrouding had no significant effect ($P > 0.05$) on fat thickness measurements made on the loin muscle at the ribbing site, but there was a trend for NSh to have a slightly greater fat thickness than Sh sides, which was more apparent in fat carcasses. Carcass cooler shrinkage was found to be significantly lower ($P < 0.001$) for NSh sides compared to Sh sides. It was concluded that shrouding had a minimal influence on carcass grading and carcass appearance and could be discontinued as a standard industry practice.

The incidence and causes of dark-colored beef in the central Alberta region. The color of the ribeye (*longissimus dorsi*) muscle of 16 594 beef carcasses was evaluated, following carcass grading at a commercial abattoir in the central Alberta region. Darker than normal beef was found in 4.0% of steer and heifer carcasses. However, the incidence of true dark cutters (i.e., dark in color and with a pH > 6.0) was estimated to be only 0.4%. Unexpectedly, the length of time between stunning and the measurement of color had a major impact on color. The incidence of dark-colored beef was three times higher at 15–18 h than at 23–26 h post-stunning, apparently because of incomplete development of muscle color at the earlier times. Many other factors influenced muscle color, including (*1*) carcass fat cover, weight, and conformation, (*2*) breed, (*3*) gender, (*4*) nutritional regime, (*5*) truck type, (*6*) transit distance, (*7*) lairage time at the packing plant, and (*8*) weather conditions. Several of these appeared to influence color by affecting the time of color measurement. Others did so by affecting carcass size and fat cover. Carcasses that were smaller, had less fat cover, or had poorer muscling yielded darker ribeye muscles, probably because they cooled more quickly, thus delaying the color development process. These findings indicate that many factors, not related to preslaughter stress, may have a marked influence on beef muscle color, especially if color is measured within 24 h after slaughter.

Meat processing

The effect of cookery method on beef palatability and cooking properties. A total of 432 boneless beef loin steaks were prepared using three different cookery methods (conventional electric oven, electric convection oven, and microwave oven), and evaluated for palatability by an experienced six-member laboratory taste panel. Cooking losses and times were also recorded. Composite results indicated that microwave cookery could not be utilized to shorten cooking times without compromising the eating quality, but that preparation time could be substantially reduced (66%), without compromising eating quality, by using convection rather than conventional cookery methods, under the conditions in which this study was conducted.

Effects of antioxidants on the retail appearance and shelf life of frozen bacon. The efficacy of three antioxidants and a reductant for preventing deterioration in factors contributing to the retail acceptability of bacon slices during frozen storage and simulated retail display was examined. The antioxidants (butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), and propyl gallate (PG)) and the reductant (ascorbic acid (AA)) were incorporated into a dry sugar bacon cure alone or in combination. Composite results indicated that the incorporation of the formulations evaluated into dry sugar bacon cures did not appear to be practical for either extending the frozen storage life or retail shelf life of frozen and thawed bacon from an appearance aspect. However, the incorporation of BHA and BHT in combination extended the retail shelf life of fresh bacon slices by approximately 3.5 days, based upon regression analysis.

Meat microbiology

Bacteriology and retail shelf of spray chilled pork. To abate evaporative losses during carcass chilling, some Canadian abattoirs have adopted a spray chill process. However, the bacteriological consequences of these water sprays have not been adequately assessed. In view of this, a study was conducted under research slaughter and dressing conditions to compare the effects of spray and conventional air chilling on the bacterial condition and shelf life of pork.

Paired sides were either water sprayed (60 cycles every 15 min) for the initial 10 h of cooler storage at 1°C or conventionally air chilled at 1°C for 24 h. Although sprayed carcasses had a slightly lower surface temperature at 6 and 10 h post-treatment, mesophilic bacterial numbers did not change significantly. Contrarily, air chilling produced a significant 0.4 log reduction in mesophiles.

Variation in the numbers of psychrotrophic or mesophilic bacteria on boneless pork loins processed 24 h postmortem could not be attributed to chilling method. Also, during 10 days of simulated retail display there were no significant differences in bacterial growth, color, and retail shelf life for loin chops derived from spray or conventionally chilled sides. It was concluded that with the levels of carcass contamination encountered in a research abattoir (in this study) 10 h of intermittent water spray did not affect the bacterial condition or keeping quality of fresh pork.

PLANT AND SOIL SCIENCE

Forage crops

Comparison of six commercial hay preservatives under simulated storage conditions. The effectiveness of six commercial hay preservatives was tested at moisture levels ranging from 15 to 35% in laboratory models of reconstituted hay. The following hay preservatives were used: Hay Mate (live bacterial culture, protease, and cellulase enzymes), Add-H (67% propionic acid partly neutralized with ammonia), Fresh Cut (25% propionic acid and unspecified amounts of other organic acids and flavorings), and Culbac (12% lactic acid and fermentation extract). These additives were representative of commercial preservatives registered for use or being tested for registration in Canada. Their ability to inhibit heating, forage quality deterioration, and mold growth was determined when applied at rates suggested by the supplier or manufacturer. After 21 days of storage in a laboratory at 20°C Add-H (1.25% w/w) was effective at all moisture levels. Fresh Cut (0.3% w/w) inhibited heating and mold growth at up to 25% moisture but did not maintain in vitro organic matter digestibility (IVDOM) at levels equivalent to unspoiled hay. Hay Savor (0.3% w/w) and Silo Guard (0.1% w/w) limited dry matter loss but did not improve IVDOM at 20% moisture. The relative performances of the preservatives containing propionic acid could be explained on the basis of actual propionic acid concentration applied to the hay. The amount of propionic acid applied in Fresh Cut and Hay Savor is below the minimum concentration for mold inhibition recommended by European researchers based on the moisture content held by the hay. By comparison, applications of Add-H at 1.25% w/w always ensured that the minimum concentrations were exceeded. In a detailed microbial analysis conducted at 25% moisture, Hay Mate and Culbac did not stimulate or inhibit anaerobic and aerobic bacterial growth. The data gave no indication of how they might aid preservation of hay in an aerobic system. It can be concluded that preservatives in the order of potential effectiveness were as follows: Add-H > Fresh Cut > Hay Savor = Silo Guard > Culbac = Hay Mate = negative check.

Cereal pathology

Snow mold infection of winter wheat in central and northern Alberta. Winter wheat (cultivar Norstar) in central and northern Alberta is often extensively damaged by snow molds. In 1986, crop losses ranged from 5 to 100%. The low-temperature basidiomycete, *Coprinus psychromorbidus* (LTB), is the major pathogen in this area; however, *Myriosclerotinia borealis* and a low-temperature pathogen found on alfalfa, *Plenodomus meliloti*, are also frequently isolated. Field studies were undertaken at Lacombe during the winter of 1986–1987 to examine the pathogenicity and subsequent development of these pathogens in artificially inoculated wheat, sown at two planting dates. Healthy and inoculated plants were sampled biweekly from mid-October to mid-April for the presence of the pathogens. LTB was recovered in early December from winter wheat crowns and subsequently from stem and root tissues. *P. meliloti* and *M. borealis* were found in February and March, respectively. The penetration and development of these snow molds in the wheat tissues as well as the changes in endogenous cytokinins in response to the infection were examined.

Cereal breeding

Jasper oat. An early maturing, high-yielding, and sprouting-tolerant oat cultivar named Jasper has been developed at the Lacombe Research Station. The cultivar is registered at the Plant Health and Plant Products Directorate, Agriculture Canada, and has been released to SeCan Association for pedigreed seed increase and distribution in Canada. Jasper originated from a Cavell–Gemini cross made in 1975, and has performed well in regional trials in Alberta. In tests conducted across Alberta, it yielded 6% more than Athabasca, a cultivar that has similar maturity rating as Jasper, and which at the present time is occupying approximately 10% (65 000 ha) of the provincial oat hectarage. The major attributes of Jasper are excellent yield-maturity index, high bushel weight, and an excellent combination of high protein, high fat, and low hull contents. Because it is susceptible to the oat stem rust (caused by *Puccinia graminis* Pers. f. sp. *avenae* Eriks & Henn.), and oat crown rust (caused by *Puccinia coronata* Cda. f. sp. *avenea*), Jasper is not recommended for production in the eastern prairies where these diseases are prevalent. The new cultivar is expected to be in commercial production in 1988.

Weed research

Graminicide tank-mixtures with DPX A7881 result in severe canola injury. DPX A7881 is an exceptional new herbicide that selectively controls broad-leaved weeds, including stinkweed and wild mustard, in conventional (triazine susceptible) canola. Other herbicides are required to effectively control grassy weed problems. Tank-mixing DPX A7881 with grass herbicides seems like an obvious method of achieving broad-spectrum weed control. However, preliminary research indicates that some of these mixtures may result in severe canola injury. The objective of the following experiments was to determine the extent of canola injury that results from tank-mix applications of DPX A7881 with grass herbicides.

Five graminicides were applied alone and in combination with DPX A7881 to Tobin canola at the 5–6 leaf stage in 1986 and 1987. Normal field rates of the herbicides were applied under ideal weather conditions with adequate soil moisture.

Canola injury was more severe in 1987 than in 1986. In 1986, DPX A7881 tank mixes with haloxyfop-methyl and fluazifop-butyl caused canola yield reductions of 68 and 43%, respectively. In 1987, the DPX A7881 tank mixes with haloxyfop-methyl and fluazifop-butyl dropped canola yields below 0.1 t/ha (untreated check yields were 1.8 t/ha in 1987). In summary, canola yield decreases were greatest when DPX A7881 was applied with haloxyfop-methyl < fluazifop-butyl > fluazifop-*p*-butyl > quizalofop-ethyl > quizalofop-ethyl (active isomer). Other preliminary experiments indicated that with the above tank mixtures, Westar canola (*Brassica napus*) was much less susceptible to injury than Tobin canola (*B. campestris*).

Soil fertility

Fate of surface applied phosphorus on (P) established forage stands. Unlike nitrogen (in nitrate form) and sulfur (in sulfate form), which move freely in soil, P is relatively immobile. For this reason, placement of P fertilizer is very critical, that is, it must be located where roots can intercept it. However, this is not practical in established forage crops, and consequently fertilizers are generally broadcast on the surface. To determine the amount of the broadcast P that moved down into the soil, field experiments were conducted in central Alberta.

Phosphorus was applied annually to an established fescue sward at 67, 134, 268, and 536 kg/ha over 7 years in a field experiment on a Black Chernozemic sandy loam soil at Lacombe. After 7 years, soil samples taken from the 0–5, 5–15, and 15–30 cm depth showed that the majority of the fertilizer P had accumulated in the 0–5 cm depth. There was some increase in extractable P in the 5–15 and 15–30 cm depth, but only at the two highest rates of applied P. At the two lower rates, very little of the applied P apparently moved below the 15 cm depth. Similarly, in a second experiment at Lacombe, where P was applied annually, or once initially, at various rates to alfalfa, most of the increase in extractable P occurred in the top 7.5 cm depth and little or none of the applied P was recovered below the 15-cm depth.

In another experiment, conducted by the Lacombe Research Station and University of Alberta at four sites, P was broadcast at 34 and 67 kg/ha for several years on bromegrass–alfalfa mixtures. At the end of that period, soils were sampled in 2-cm increments to a depth of 14 cm and the extractable P was measured. The extractable P concentrated most in the 0–2 cm depth and it decreased with depth until no added P was recovered at the 10–12 cm depth. Greater movement occurred with the higher application (67 kg/ha) and on the coarse-textured soil (Site 2).

Other work had suggested that broadcast application of P fertilizer would not be effective in the year of application because the P remained on the soil surface. The results reported here show, however, that some fertilizer P moves into the upper part of the soil over several years. This added P will be partly available to plants as long as the soil remains moist so that roots are active, but it may not meet crop requirements. Further research work on P fertilization of forages is needed to compare the efficiency of annual applications to one high application at the time of establishment, and to seek other methods to increase the efficiency of the P applied to established forage stands.

SOILS AND CROPS SUBSTATION VEGREVILLE

Solonetzic soils

Soil chemistry 10–20 years after deep plowing. Three sites were intensively sampled in July and August 1986 to determine the long-term effects of deep plowing Solonetzic soil. Site I was deep plowed to 55 cm in July 1975, Site II was deep plowed to 70 cm in October 1976, and site III was deep plowed to 60 cm in October 1967. Sampling depths were selected to most likely represent the Ap, Bnt, and Csa horizons of an undisturbed Solonetzic soil. At each site, corresponding yield samples were also taken to determine crop productivity as affected by soil conditions. At each site, check strips and deep-plowed strips were sampled. Significant yield increases due to deep plowing occurred at all three sites, with the plow treatments yielding 156%, 157%, and 118% of check treatments for sites I, II, and III, respectively. Significant decreases in the sodicity of the Bnt horizon also occurred at all three sites with plow and check sodium absorption ratios of 13.4 and 10.0 for site I, 13.8 and 10.4 for site II, and 12.9 and 8.0 for site III. This represents a very substantial change in soil chemistry that would appear to be long-term. Similarly, calcium concentration in the Ap horizon increased significantly at all three sites as did soil pH; however, this was significant only for sites I and II. This indicates that deep plowing may be a viable method of ameliorating Solonetzic soils, because the high initial cost may be offset by the long-term improvement in soil chemical characteristics. Further research is required to determine if deep plowing can be combined with other promising treatments to further improve the amelioration of Solonetzic soils, particularly improving the initial seedbed quality.

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R.H. Robertson, B.A., M.Sc. Retired December 1987	Serology
J.L. Shipp, B.Sc., M.Sc., Ph.D. Transferred to Harrow Research Station, August 1987	Black-fly ecology
S. Smoliak, B.Sc., M.S. Retired October 1987	Acting Head of Section; Dryland pastures
J.A.P. Vesely, B.S.A., M.S.A., Ph.D. Retired November 1987	Sheep and dairy cattle breeding
J.M.B. Yeung, B.Sc., Ph.D. Resigned August 1987	Pesticide metabolism

VISITING SCIENTISTS

M.E. Leggett, Ph.D. Philom Bios	Phosphate solubilization
G.D. Radder, Ph.D. Canadian International Development Agency (CIDA) senior fellow, India–Canada Dryland Project	Agronomy

Postdoctorate fellows

H. Kudo, Ph.D.	Rumen microbiology
Khoon-Sin Tan, Ph.D.	Nuclear magnetic resonance (NMR) spectroscopy

Agriculture Canada research scientist training fellow

J. Chiquette, M.Sc.	Rumen microbiology

Commonwealth scholarship doctoral student

D. Sabwa, M.Sc.	Fungal parasitism of mosquito

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[1] Appointed August 1987.

[2] Appointed August 1987.

[3] Seconded from Libraries Division, Corporate Management Branch.

[4] On educational leave, Oregon State University, September 1984 to August 1987.

[5] On educational leave, North Carolina State University, August 1985 to August 1988.

[6] On transfer of work, Institut national de recherche agronomique (INRA) station de bioclimatologie, Montfavet, France, August 1987 to August 1988.

[7] Seconded to Pesticides Directorate, Ottawa, November 1987 to October 1988.

[8] On transfer of work, Tanzania–Canada Wheat Project, Arusha, Tanzania, August 1985 to August 1987.

[9] On transfer of work, Rothamsted Experimental Station, England, February 1987 to February 1988.

[10] Seconded to Priorities and Strategies Directorate, Research Branch, May 1987 to April 1988.

INTRODUCTION

The research station at Lethbridge, in southern Alberta, is located at the centre of one of the most diverse agricultural regions in Canada. A wide variety of crops is grown on both dry and irrigated land, and a major part of Canada's beef cattle industry is established on the farms and ranches within and around the region.

Station scientists conduct fundamental and applied research in support of 13 Research Branch objectives. In addition to the 500-ha site at Lethbridge, the station conducts research at a 17 000-ha beef cattle ranch near Manyberries, a 400-ha ranch near Stavely in the foothills of the Rocky Mountains, and a 130-ha irrigation substation at Vauxhall. Fundamental and applied research focuses on plant breeding, the control of plant diseases and insect pests, soil fertility, tillage, water use, livestock improvement and nutrition, and the control of livestock pests.

Crop production and improvement research deals with the breeding and genetics of 12 different species or crop kinds, the study of the biology and control of a wide range of plant diseases and insect pests, and the development of improved agronomic practices related to soil fertility, tillage, and water use. Related studies on physical, chemical, microbiological, and hydrological aspects of soil provide guidance for the introduction of methods to maintain or improve the soil resource.

Livestock research is concerned with evaluating the effects of breed or selection methods on the improvement of beef or dairy catttle, and of breed and management on sheep productivity. Other studies on nutrition, rumen microbiology, and physiology contribute to the development of efficient methods of beef cattle production. The station is also a major centre for the study of arthropod pests of livestock.

In 1987, the traditional six research sections were realigned into three larger units–Livestock Sciences, Soil Sciences, and Crop Sciences. This change will improve intersection cooperation and efficiency and encourage the formation of productive interdisciplinary teams.

Several staff changes occurred at the station during 1987: Mr. B.D. Clark, administrative officer – finance and materiel management, transferred to Toronto; Dr. J.L. Shipp, entomologist, transferred to Harrow; and Mr. D.W. Pang, computer systems manager, transferred to Calgary. Dr. P. Bergen, weed scientist, and Dr. J. Yeung, toxicologist, resigned. Dr. J.C.M. L'Arrivée, information officer; Dr. G.A. Kemp, bean breeder; Dr. D.C. MacKay, soil scientist; Dr. D.W.A. Roberts, plant physiologist; Mr. R. Robertson, serologist; Mr. S. Smoliak, range grass breeder and acting head, Cereal Crops Section; and Dr. J.A. Vesely, sheep breeder, retired after long and distinguished careers at Lethbridge.

Several appointments were made: Mr. J.E. Lawson was named head, Livestock Sciences Section, which was an amalgamation of the former Animal Science and Animal Parasitology sections; and Dr. D.L. Struble was named head, Crop Sciences Section, which was a consolidation of the former Plant Science and Plant Pathology sections. Dr. P.A. O'Sullivan was appointed assistant director, replacing Dr. D.L. Struble, who had served as acting assistant director and section head; and Mr. M. Parent was named head, Administration, replacing Mr. B.D. Clark, who had been acting head. Dr. J.M. Carefoot completed his educational leave and joined the Soil Science Section as an irrigation agronomist.

Our scientists hosted visiting scientists and foreign delegations, and participated on graduate students' thesis committees, international secondments, and exchanges. They also served on numerous provincial, national, and international committees. Several of our clients participated directly in our research activities; Farming for the Future of Alberta Agriculture partially funded 14 projects, the Western Grains Research Foundation funded five projects, and new collaborative research was initiated with several companies.

The short reports that follow give results of some recent research and illustrate the types of studies that are under way. Further information may be obtained from publications listed at the end of the report or from our scientists. Correspondence or requests for reprints should be addressed to the Research Station, Research Branch, Agriculture Canada, Lethbridge, Alta. T1J 4B1; Tel. (403) 327-4561.

D.G. Dorrell
Director

CROP PRODUCTION

Cereals

Nutritional quality of protein in Norstar winter wheat. The protein content and nutritional quality of whole wheat and milling fractions of a winter wheat cultivar, Norstar, were compared with its parents, Winalta and Alabaskaya. Alabaskaya contributed to the superior winterhardiness of Norstar. Although Winalta has a relatively high protein quality and Alabaskaya a relatively low protein quality, the progeny, Norstar, had a quality surpassing even that of Winalta. Norstar also had the highest protein quality in flour. This shows that Alabaskaya did not adversely affect the protein quality of Norstar. Norstar is well-adapted in the Prairie Provinces; in 1987 it occupied more than 90% of the nearly 400 000 ha seeded with winter wheat.

Corn

New corn inbred. Inbred CL30 was released under the new agreement between Agriculture Canada and Canadian seed corn companies. This line was selected through inbreeding from the Lethbridge Gene Pool population that was started in 1976. Initially, the population consisted of exotic maize from Mexico, New England flint corn, and two Canadian hybrids. Mass selection was practiced to advance the date of silking and improve the stalk strength of the population. Inbred CL30 contributed early maturity, characterized by low moisture at harvest, good stalk strength, and good grain quality in many hybrid combinations with lines developed at Ottawa, Brandon, and Morden research stations. Canadian seed corn companies will now have the capability to develop very early maturing and high quality hybrids. It also means that grain corn production in western Canada can expand into lower heat unit areas (2000 CHU, corn heat units).

Soybeans

Use of near-infrared reflectance spectroscopy (NIRS) to screen soybean lines for plant nitrogen. In order to select breeding lines of soybeans for an enhanced ability to support nitrogen fixation by *Bradyrhizobium japonicum* Jordan, a fast screening method for determining the nitrogen content of the plants is required. It was determined that NIRS could be used as such a method. Soybean lines were grown in the field under different inoculation treatments and in growth cabinets with different nitrogen fertilizer treatments to cover a wide range of plant nitrogen. Regressions were run on ground plant samples to select the best of 19 filters compared to laboratory Kjeldahl nitrogen determinations. Statistical tests on the regressions showed that selections of soybeans grown in the field and growth cabinet could be combined for accurate predictions of nitrogen content in the plants at flowering and at maturity. These NIRS calibrations were on the average more highly repeatable for predicting nitrogen content than were individual Kjeldahl determinations.

Potatoes

Evaluation of the diagnosis and recommendation integrated system (DRIS) procedure for assessing the nutritional status of potato. The DRIS procedure for assessing nutritional status of plants by leaf analyses utilizes standard values (norms) for nutrient ratios that have been obtained from high-yielding populations. Examination of 1086 sets of yield and analytical data from 28 field experiments with potato (*Solanum tuberosum* L.) conducted over a period of 8 years on irrigated Boroll soils in semiarid southern Alberta, established ratios among N, P, K, and Ca that were significantly less variable in the high-yielding (>40 t/ha) than in the low-yielding population. Ratios for N, P, K, and Mg, determined from 1260 data sets obtained from 5 years of experimentation on Spodosol soils in the temperate humid area of Nova Scotia, were similar to those from the Boroll soils. Nutrient indices of deficiency, which were computed to integrate the degree of departure of each ratio from the standard norms, predicted deficiencies of N and P reasonably well at Boroll test sites, with the use of either Boroll or Spodosol norms. On Spodosol sites, the indices correctly predicted deficiencies of all three nutrients but tended to underemphasize N deficiencies and to overemphasize deficiencies of P and K. Although the DRIS procedure generally identified deficiencies, it could not predict accurately the yield responses obtained nor the quantities of fertilizer nutrients required at various sites in different years. As has been reported for other crops, the specific plant growth stages at which samples were collected were less crucial than has been found necessary for the critical nutrient level method of diagnosis.

Detection and correction of phosphorus (P) deficiency in irrigated potatoes. Three experiments were performed in an automatic rainshelter and two in the field to determine the role of soil moisture management and P fertilization in controlling P nutrition of potatoes (*Solanum tuberosum* L. 'Russet Burbank'). The rainshelter experiments indicated that permitting the upper 25 cm of soil to remain dry during the early part of the growing season depressed the total P concentrations in the leaf blades at the 10%-bloom stage to well below the sufficiency range of 0.45–0.50%, despite high P application rates at planting. Relieving stress at 10% bloom and maintaining soil water potential between –60 and –20 kPa until harvest significantly increased P concentrations. Tuber yields were only slightly less than on those soils without water stress throughout the growing period, provided ample P had been applied. By delaying stress relief in the upper soil layer for 3 weeks, 6 weeks, or until maturity, tuber yields were reduced 28, 47, and 49%, respectively. Without P fertilization of this P-deficient soil at planting, leaf-P levels at 10% bloom were very low (0.26%), but application of P at this stage (banded, broadcast, or in solution) increased leaf-P concentrations and yields were similar to those in treatments receiving P at planting. Trimetaphosphate was particularly effective in increasing P concentrations in the leaves. In the two field experiments, tuber yields were high on all plots and treatment differences were small, even though leaf-P concentrations were relatively low. However, in the highest-yielding treatment (banded at planting) leaf-P levels averaged 0.40–0.49%. From the practical standpoint, leaf analysis at the early bloom stage can be used to detect P deficiency, which may be caused by inadequate P fertilization or early season soil water stress. If soil and fertilizer P are insufficient, immediate application of fertilizer P will correct deficiencies and enhance yields if adequate soil water is also provided. Soil moisture stress from early bloom to near maturity should be avoided with this crop to obtain efficient use of applied P and maximum yields of tubers.

Forage crops

Cicer milkvetch pollinators. Twenty-seven species of bees were identified as pollinators of cicer milkvetch in southern Alberta. At Lethbridge, honey bees comprised 74% of the observations, bumble bees 16%, and leafcutter bees 10%. At Spring Coulee, the proportions were honey bees 14%, bumble bees 69%, and leafcutter bees 17%. The rate of foraging by bee species varied; bumble bees foraged consistently more efficiently than honey bees or alfalfa leafcutter bees. A theoretical approach was used to predict the bee populations required to pollinate varying flower densities. The number of *Bombus nevadensis* Cress. required was about 50% those of *B. huntii* Greene and the alfalfa leafcutter bee and less than 25% that of the honey bee. Pollination by *B. nevadensis* consistently resulted in more seeds per pod than with any other bumble bee species, the honey bee, or the alfalfa leafcutter bee. Of the nine species of bumble bee that established colonies in artificial domiciles near the field, *B. nevadensis* established the most colonies each year. The number of workers and sexuals produced per colony varied considerably among species and years. The propagation rate and quality of alfalfa leafcutter bees produced was excellent.

Rangeland

Stability of grazed patches. The stability of grazed patches in the fescue grassland area was studied in fields that had been stocked with cattle at a fixed rate since 1949. Results showed that season-long stocking of native range led to the formation of stable patches of grazed micro-sites characterized by seral plant species, reduced production, and soil degradation. Forage production was 37% less and the depth of the Ah horizon 28% less than on contiguous ungrazed patches. Although heterogeneity in the grasslands is desirable for uses other than livestock production, such as wildlife and waterfowl, patch stability should be prevented. Livestock management techniques that include adjusting stock density and the time of grazing will prevent the deterioration of vegetation and soil that results from repeated grazing.

Revision of manual describing range pastures. A manual describing grazing management on range pastures of Alberta was revised and published. This manual provides information that will enable ranchers and government personnel to determine the optimum stocking rates for nine prairie pasture types.

CROP PROTECTION

Cutworms

Population studies. Pale western cutworm caused little damage in 1987 and only about 1000 ha were treated with insecticide for its control, compared with 70 000 ha in 1986 and 295 000 ha in 1985. The annual cutworm forecast, based on sex-attractant monitoring of moth population levels, had correctly predicted the decline in abundance. The moth population of this species has declined a further 36%, consequently damage by pale western cutworm in 1988 is unlikely. However, the moth population of army cutworm increased to the highest level since monitoring began in 1978 and some damage by this species is likely in early spring of 1988. Populations of redbacked cutworm and bertha armyworm are currently at low levels in southern Alberta.

Results of a sex-attractant monitoring study conducted from 1978 to 1985 at 81 permanent sites within a 13 000-km^2 study area showed that monitoring at as few as five sites could track changes in abundance and enable forecasting of outbreak potential for all eight species studied. Based on these results a surveillance monitoring system for the three major pest species of cutworms and the bertha armyworm has been established throughout Alberta in cooperation with Alberta Agriculture.

Pheromone study. Sex pheromone components were identified in extracts of adult females of strawberry cutworm (*Amphipoea interoceanica* (Smith)) and a blend of (*Z*)-9-tetradecenyl acetate and (*E*)-11-tetradecenyl acetate at 200:40 μg per dispenser was an effective attractant for the male moths. This species has become an important pest of strawberry plants in Manitoba and Quebec. The attractant will be useful for monitoring the abundance of male moths and for timing insecticide controls.

Grasshoppers

The 1988 Alberta forecast. In 1987, grasshopper abundance, crop damage, and area sprayed in Alberta declined for the 2nd year in a row. The preliminary estimate of insecticide used for grasshopper control in Alberta in 1987 is less than half of that used in 1986. The total areas sprayed for grasshoppers in 1983–1986 were 47 750, 224 400, 595 550, and 387 700 ha, respectively, based on estimates obtained from Agriculture Service Board Fieldmen and District Agriculturists.

The 1986–1987 decline in grasshopper numbers is not attributable to disease. The fungus *Entomophaga grylli* has increased its prevalence as a grasshopper mortality factor but has resulted in the death of less than 5% of the grasshoppers at surveyed sites. Analysis of the changes in numbers of susceptible and resistant species indicates that the decline of the outbreak was not caused by disease. The direct effects of weather on reproduction and hatching success provide a more likely explanation.

The forecast for 1988 indicates low to moderate infestations except in southwestern counties. Some small areas near Fort MacLeod and in Cardston county still have severe infestations. A total of 1.2 million hectares fall into the severe and very severe categories. Less than one-fourth of this area is expected to require insecticide application.

Spatial analysis of historical grasshopper outbreak data. A geographic information system with modeling capability was used to analyze the relationships of grasshopper outbreaks to soil type and weather over a large area. The system allows true spatial modeling and is not based on point averages, as previous attempts have been. The new Alberta grasshopper data base includes contour maps of grasshopper density for 1970–1987, weather variables for the past decade, the Canadian soil information system (CanSIS) soils database, and insecticide use by location, quantity, and product for 1985–1986.

Other insect pests

The brown wheat mite increased in abundance from 1986 and high populations were present in many fields of barley and winter wheat in southern Alberta, especially fields that had been continuously cropped to cereals. Many heavily infested barley fields showed pronounced yellowing in late May and early June. About 1000 ha were sprayed with insecticides in attempts to control this pest. Populations declined naturally throughout June as diapause eggs were produced and, with adequate moisture, most infested crops appeared to recover by late June. Reliable data on the effect of the brown wheat mite on crop yield are lacking but producers estimate a 20–30% yield reduction for barley.

The historical and recent occurrences, and the biology of a woolly-bear caterpillar, *Grammia blakei*, which is occasionally abundant on overgrazed native range pastures in southern Alberta and southwestern Saskatchewan, were documented. Infestations of this insect reduce early season productivity of rangeland and sometimes damage adjacent cultivated crops. Its economic impact is highly variable and dependent on spring moisture conditions.

Wheat stem sawfly is again becoming of concern across the southern prairies and there have been widespread reports of slight to moderate damage. Several factors including dry summers, conservation tillage, recropping, and use of highly susceptible varieties have contributed to the resurgence of this pest.

Insecticide residue chemistry

Aerial application studies. Deltamethrin deposition was measured by conducting residue analysis on natural substrates (i.e., soil and vegetation). In three experiments, the mean deposition was 63, 73, and 76% of applied. The use of Teflon discs as artificial targets to measure aerial deposition was also investigated. The discs had only 34–71% mean trapping efficiency for the spray droplets and deposition was quite variable (coefficient of variation 73–83%) among different sampling sites within a field. Much of this variation was caused by irregular overlapping of spray swaths.

To monitor pyrethroid deposits in environmentally sensitive areas, a silica gel impingement plate was developed. The plate was simple, commercially available, and inexpensive. A residue analysis method was used to recover deltamethrin deposits from the plate with 87.5% efficiency. The minimum quantifiable limit was 0.005 µg per plate. Deposits were strongly adsorbed to the silica gel and were not washed off by rainfall or readily photodegraded. In two field experiments, deltamethrin was detected 3 weeks after direct spray applications of active ingredient (a.i.) at 6 and 10 g/ha. Deltamethrin dissipation on the plates was first-order with a half-life of 2.9–4.3 days.

Cereals

Black point resistance. A multilocation field study determined that the wheat cultivars Sinton, Park, Thatcher, Benito, Era, and Glenlea and the soft white spring wheat line SWS15 were black point-resistant. Tests against two fungi, *Alternaria alternata* and *Cochliobolus sativus*, revealed significant differences in black point incidence among wheat cultivars. All the cultivars were significantly more resistant to *A. alternata* than the susceptible cultivar Fielder. Glenlea and Era were more resistant to *A. alternata* than all the other cultivars. Only the cultivars Thatcher, Benito, and Sinton were more resistant to *C. sativus* than Fielder. Direct comparisons of the two fungi found that *C. sativus* produced significantly less disease in Fielder and Sinton than *A. alternata*, but the opposite was true for Glenlea. This suggests that resistance to *A. alternata* and *C. sativus* is under different genetic control in certain cultivars. This information will assist wheat breeders in the development of superior spring wheat cultivars.

Snow molds on winter cereals in central and northern Alberta. A survey for the incidence and distribution of snow molds on winter cereals in central and northern Alberta and northeastern British Columbia was conducted in early spring from 1983–1987. The nonsclerotial form of cottony snow mold was the most prevalent snow mold fungus and was responsible for severe reductions in winter survival of winter cereals. The sclerotial form of cottony snow mold was infrequently recovered from diseased plants, but it was commonly observed on decaying leaves of deciduous trees in the Peace River district. Snow scald and pink snow mold were also infrequent. The results of this survey will serve as a basis for initiating a breeding program to develop winter wheat and fall rye varieties resistant to snow molds.

Development of resistance to cottony snow mold. The effects of hardening and plant age on development of resistance to cottony snow mold in winter wheat were studied under controlled conditions. Resistance was measured by the percentage of inoculated plant surviving after incubation at -3°C for 8–12 weeks. The number of weeks of prehardening growth prior to inoculation, fresh weight, LT50 (50% killing temperature), and tiller number were positively correlated with resistance to cottony snow mold. Development of resistance to cottony snow mold was most influenced by amount of pre-hardening growth, and the development of freezing resistance played a minor role in the development of disease resistance. The results of these studies will be employed in a screening technique for the selection of resistant genotypes under controlled conditions.

Development of microsclerotia in nonsclerotial (LTB) strains of cottony snow mold. The development of microsclerotia in LTB strains of cottony snow mold was studied, using light, scanning, and transmission electron microscopy. In winter wheat in a controlled environment, microsclerotia consisted of thick-walled, spherical cells formed by budding of filamentous hyphae cemented by a intercellular matrix. These structures are the putative survival structure for LTB forms of cottony snow mold. These results are important in understanding the ecology and distribution of the different forms of the fungus and devising a strategy for control of cottony snow mold.

Take-all resistance. The wheat-alien chromosome substitution line Winalta–*Aegilops squarrosa* 6D was shown in a series of tests to be resistant to the fungal root disease take-all. Take-all severity was significantly lower in Winalta–*A. squarrosa* 6D than in Winalta at low and moderate inoculum concentrations, but no differences were apparent at high inoculum concentrations. Field trials conducted over a 3-year period confirmed that Winalta–*A. squarrosa* was resistant to take-all. These differences in take-all severity between Winalta and Winalta–*A. squarrosa* 6D also resulted in higher plant weights. Other chromosome substitution lines in the Winalta–*A. squarrosa* substitution series were not consistently better than Winalta. Similarly, substitutions for chromosomes 5D and 6D in Winalta by homologous chromosomes from *Agropyron elongatum* and chromosome 4B for chromosome 4 from *Agropyron intermedium* had no effect on take-all resistance. The wheat–*Agropyron trichophorum* amphiploid Agrotana was also susceptible to take-all. This is the first report of the successful transfer of take-all resistance from an alien species into hexaploid wheat. The Winalta–*A. squarrosa* 6D line will be useful in the development of soft white spring wheat cultivars with improved resistance against this fungal root disease.

Wheat streak mosaic virus. The wheat curl mite is the vector of both wheat streak mosaic virus and the wheat spot mosaic agent, which are potentially damaging diseases of common wheat. One of the group 6 chromosomes of tall wheat grass, *Agropyron elongatum* (Host) Beauv., confers resistance to colonization by the wheat curl mite. The transmission of this alien chromosome was evaluated when added to or substituted for the group 6 homoeologues in two cultivars of common wheat. A wheat-alien translocation was detected in backcross progeny from these studies and resulted in resistance to colonization by the wheat curl mite being transferred to a wheat chromosome. Studies of four enzymes that are encoded by genes on the group 6 homoeologues of wheat identified the normal and translocated alien arm. One of the enzymes, amino peptidase-1, can be monitored in seedlings to identify homozygous lines in 2–3 weeks rather than 12–18 months by conventional methods. This will improve the efficiency of breeding for resistance.

Field crops

Sclerotinia sclerotiorum is the most important disease of dry beans, canola, and sunflower in southern Alberta. The pathogen overwinters in the soil as black sclerotial bodies. Previous investigations revealed that the fungus *Coniothyrium minitans* is a hyperparasite, effective in destroying sclerotia of the white mold pathogen under field conditions. Recent ultrastructural studies on the mode of hyperparasitism indicate that hyphae of the hyperparasite invade the sclerotial bodies, resulting in the destruction and disintegration of the sclerotium tissues. Evidence from cell wall etching and cell wall invagination at the point of hyphal penetration suggests that both chemical and physical activities are involved in the penetration of the thick, melanized rind walls of the sclerotia. The medullary tissue of the sclerotia is destroyed by the hyperparasite through the process of plasmolysis, cell wall dissolution, and aggregation and vacuolization of cytoplasm.

Low temperature injury in potato seed tubers. Field trials were conducted in Alberta (Vauxhall Research Substation) with Norchip, Norland, and Russet Burbank and in Ontario (University of Guelph Research Farm, Cambridge) with Kennebec, Russet Burbank, Norchip, and Superior tubers to determine their response to short-term exposure to air temperatures of 0, -1, and -5°C and to long-term exposure to -1, 0, 1, 2, and 3°C. Exposure of seed tubers to -1°C from 6 h to 5 days did not affect growth characteristics or tuber yield of any of the five cultivars studied. Long-term

(October–May) exposure to −1°C in the Alberta study severely reduced emergence and tuber yield of Norchip ($P < 0.05$). Although the marketable yield of Russet Burbank was also reduced ($P < 0.05$) by this treatment, Norland was not affected. Tubers of all cultivars exposed to air temperatures of −3 or −5°C for longer than 24 h were severely injured and were not planted in the field trials at either location. In Alberta, exposure of seed tubers of Norchip, Norland, and Russet Burbank to −5°C for 6 and 12 h caused a slight reduction in yield. In Ontario, long-term storage at 1, 2, and 3°C and in combination with short-term (2 weeks) exposure to 0 or 10°C had no effect on growth or marketable yield of Norchip, Russet Burbank, Superior, and Kennebec seed tubers.

This study indicates that although short-term exposure to 0 or −1°C temperatures did not adversely affect growth of the five cultivars, cultivars differ in susceptibility to long-term exposure and that this can cause serious yield losses in susceptible cultivars. It is also apparent that while seed tubers exposed to −5°C for 12 h did not freeze, this treatment adversely affected subsequent growth and yield.

Influence of temperature and latent potato viruses on ring rot symptoms of Russet Burbank potato plants. A 5-year study showed that Russet Burbank potato plants root-inoculated with ring rot bacteria and grown at 21°C developed typical wilting and yellowing symptoms of ring rot that were equally severe on virus-free plants and on plants infected with potato viruses S and X. All virus-free and virus-infected plants inoculated with ring rot bacteria and grown at 15°C exhibited atypical symptoms that included rosetting, or bunchiness, of leaflets on the stem tips, extreme stunting, and yellowing of the leaflets. Atypical symptoms were more severe on virus-infected plants than on virus-free ones. Atypical symptom severity ratings were highly related to the final fresh weight of plants with high severity ratings being associated with low fresh weights. These findings point out the need to determine the role of temperature and viral pathogens on ring rot symptoms in existing and newly developed potato cultivars to enable better field detection of bacterial ring rot.

LIVESTOCK SCIENCES

Rumen microbiology

Isolation of cellulolytic bacteria. Medium enriched with Whatman No. 1 cellulose filter paper as the sole selective substrate was very effective in the isolation of cellulolytic bacteria from the rumen of a steer in Canada and a water buffalo in Malaysia. Both animals had been fed high-fiber diets. Rumen samples were incubated in enrichment broth medium for 36 h prior to inoculation into nonselective glucose–cellobiose–starch agar roll tubes. From these, 120 colonies were picked and 45 were cellulolytic. Also, 36 out of 90 colonies obtained from the water buffalo sample were cellulolytic. Most were identified as *Bacteroides succinogenes*. *Ruminococcus flavefaciens* were found less frequently. Contamination by *Butyrivibrio* species was noted. The method is effective and requires less time than the conventional cellulose agar method. It is superior to the latter because pure colonies of *Bacteroides succinogenes* are detected as being cellulolytic in broth cellulose medium, whereas they escape detection by the conventional cellulose agar method because they fail to produce clear zones.

Differences in cellulose systems of bacteria. A study was made of the adaptability and characteristics of 37 fresh isolates of cellulolytic rods identified as *Bacteroides succinogenes* and seven cellulolytic cocci identified as *Ruminococcus flavefaciens* isolated from the rumen of a straw-fed steer. All 37 strains had completely lost cellulolytic capability after 10 weeks of storage at 4°C, and had lost viability after 11 weeks. Frequent transfer of cultures of *B. succinogenes* promoted high levels of cellulolytic activity, whereas prolonged intervals between culture transfer markedly reduced this activity. When *B. succinogenes* was incubated with filter paper in a liquid medium, the paper was degraded in long straight lines that eventually fragmented the piece of filter paper. In contrast, the first signs of cellulolytic attack by *R. flavefaciens* were small yellowish clear circular spots on the paper, which subsequently disintegrated to form a viscous lump. These differences in the pattern of filter paper digestion may reflect differences in the cellulase systems of these organisms.

Forage digestibility

Tannins affect the digestibility of bird's-foot trefoil. Two isosynthetic strains of bird's-foot trefoil were used for in vitro and in sacco trials. With forage grown in the greenhouse (with tannin levels of 1 and 5%, on a dry matter basis), lower tannin levels were associated with higher dry matter (DM) digestibilities. When field-grown forage (with tannin levels of 1 and 3%) was used for sheep-feeding trials, DM digestibility between the two strains was no longer different. It would be useful to improve the digestibility of bloat-free bird's-foot trefoil by reducing tannin levels through selective breeding. It appears that there exists a threshold level of tannin (3–4% of dry matter) at which the bloat-safe characteristic of the forage is still retained but below which dry matter digestibility is no longer significantly increased. Such feed material has the additional merit of containing higher levels of bypass protein.

Warble grubs

Bacterial toxins enhance immunity to cattle grubs. Resistance to cattle grub infestation in calves can be enhanced by treatment with immunopotentiators such as bacterial toxins. Calves were administered the cell walls of *tubercle bacilli* (Bacillus Calmette-Guérin; BCG), endotoxin extracted from *S. typhimurium*, or endotoxin plus cattle grub antigen prior to infestation with known numbers of cattle grub larvae. Subsequently, the status of the immune response and survival of grubs was monitored. Animals receiving the immunopotentiators had enhanced specific and nonspecific cellular immune responses after treatment. Immune responses were elevated for up to 12 weeks post-treatment. Peak grub populations were significantly reduced in animals receiving either BCG cell walls or endotoxin plus antigen. The number of grubs dropped was significantly affected by all three treatments. The most significant reduction was observed in animals treated with endotoxin plus antigen in which only 4.9% of grubs injected dropped out of the backs compared with 30.8% in controls. It is evident that immunopotentiators can enhance immunity to cattle grubs and thus have potential as components in a vaccine.

Enzyme-linked immunosorbent assay (ELISA) test for cattle grub infestation. A micro enzyme-linked immunosorbent assay (micro-ELISA) was developed and evaluated for early detection of cattle grub infestation in calves. Sera from over 300 calves from southern Alberta were tested at weaning for the presence of antibodies to cattle grubs. These calves were later exhaustively examined for the presence of warbles containing developing cattle grubs. The micro-ELISA was 95% accurate in detecting uninfested calves. Calves with mixed infestations of *Hypoderma bovis* and *H. lineatum* were detected with complete accuracy, regardless of the level of infestation. Test accuracy was approximately 50% for those calves with low levels of *H. bovis* infestation (peak counts of 1–4 grubs). For calves with moderate levels of *H. bovis* infestation (peak counts of 5–10 grubs) the test accuracy increased to 71%. This micro-ELISA test for cattle grub antibodies has potential use as a tool for monitoring the effectiveness and progress of large-scale grub control or eradication programs. Modifications to the technique may eventually allow use by producers to identify infested animals so that insecticide use can be targeted to those animals.

Pyrethroids may enhance hatch of grub eggs. Cattle ear tags impregnated with synthetic pyrethroid insecticides are commonly used by livestock producers to protect their cattle from horn fly and face fly attack. Many producers have presumed that these ear tags will also be effective in reducing cattle grub infestation. Exposure of cattle grub eggs to various concentrations of pyrethroid insecticides under laboratory conditions produced no ovicidal effect. In fact, these insecticides appeared to stimulate increased hatch of the exposed eggs. Hatch of eggs not exposed to pyrethroids was 43.4%, whereas hatch of eggs exposed to fenvalerate was 69.1%, to permethrin was 69.6%, and to cyhalothrin was 62.5%. These results are preliminary and need to be confirmed by on-animal trials.

SOIL SCIENCE

Soil management and conservation

Quality and value of wind-erodible soil aggregates. Even though wind erosion is a natural process, it can be accelerated as a result of the activities of humans. Often, the cost of erosion is expressed in terms of reduced crop yields. However, there is little information available on the quality and value of the actual airborne topsoil. Wind-erodible aggregates smaller than 1000 μm diameter from Ap horizons of recently or long-term cultivated Brown, Dark Brown, and Black Chernozemic soils were obtained and analyzed for organic matter, total N, available P, exchangeable K, and monosaccharides. The wind-erodible fraction comprised 65–76% and 89–96% of the whole soil of the Ap horizons of the recently and long-term cultivated soils, respectively. The data allowed the calculation, using a number of assumptions, of the value of soil lost by wind erosion if its nutrients and organic matter had to be replaced by commercial fertilizers and cereal straw, respectively. The smaller than 100-μm-diameter fraction usually had the highest contents of N, P, and K, and always the largest straw replacement values, compared with the aggregates larger than 100 μm diameter but smaller than 1000 μm diameter. The calculated potential economic losses when all material smaller than 1000 μm diameter would be eliminated by erosion from the upper 5 cm ranged from $6700/ha for recently cultivated Brown Chernozemic soil to $86 900/ha for recently cultivated Black Chernozemic soil. These values underscore the potential value of topsoil and importance of soil conservation practices to prevent soil erosion by wind.

Nitrogen fertilization of irrigated soft white wheat. Soft white wheat (cultivar Fielder) was grown under irrigation for three seasons in southern Alberta to compare preplant fertilizer nitrogen (N) and fertilizer applied during irrigation at several stages of plant growth. Irrigation was provided to maintain soil water above 50% of the soil field capacity. Nitrogen fertilization applied during irrigation gave crop yield responses similar to those of preplant fertilizer N in all 3 years. Crop yield response to fertilizer N was related to initial available N. Grain yields ranged from 1601 to 5700 kg/ha over the 3 years. Curtailing irrigation at early maturity resulted in reduced yields. In addition, restricted irrigation produced N concentrations in the grain that were much greater than the acceptable level of 2.13% for soft white wheat for all fertilizer treatments. When crops were irrigated to maturity, grain N concentrations did not exceed the upper limit of 2.13% for either the preplant N or the split-application N treatments.

Microbiology

Soil bacteria alter wheat root growth. Greenhouse and laboratory experiments were conducted to evaluate the effect of two soil bacteria, *Azospirillum brasilense* and *Bacillus* C-11-25, on the growth of spring wheat under sterile conditions. In the course of the experiments it was observed that Fielder wheat plants inoculated with the bacteria had longer roots than those without added bacteria. Further work showed that the inoculated plants also had reduced NO_3 uptake rates when compared with uninoculated controls. It is theorized that the bacteria were producing a plant growth-regulating substance (PGRS), since the addition of bacterial filtrates caused the same observed effects. Further evidence supporting the theory that the bacteria are producing a PGRS is that similar changes in root growth were caused by the addition of gibberellic acid. It was observed that inoculated Fielder wheat plants had root systems that were shorter and bushier than uninoculated plants in a field experiment, confirming that the bacteria affect wheat root growth in soil. This evidence points to a new role of soil microorganisms in the growth of plants.

Soil salinity

Cause of barley yield decline in saline soil. Soil salinization has resulted in serious deterioration of an expanding area of soils in western Canada. Recent estimates suggest that approximately 2.2 million hectares of land are affected and further expansion of this area is expected. Although the physical and hydrological processes contributing to soil salinity have been identified, the nutritional response of crops grown in saline western Canadian soils is not well understood. A greenhouse study was initiated to identify possible nutrient deficiencies induced by soil salinity in barley, a relatively salt-tolerant crop species. In this study, barley was grown in soil salinized to varying degrees with several different salts characteristic of those found in western Canadian saline soils. The results implicated calcium deficiency as one mechanism of yield suppression in saline soils. A strong negative relationship was observed between degree of salinity and calcium concentration in the plant tissue. Furthermore, this decline in calcium uptake was associated with reduced yield in a manner indicative of induced calcium deficiency. The apparent calcium deficiency induced by salinity stress was attributed to reduced activity in the soil solution because of precipitation with sulfate and high ionic strength. Alleviation of this calcium deficiency by breeding more tolerant cultivars or by development of appropriate agronomic practices may reduce yield suppression of barley caused by salinity.

Mole drainage for saline waterlogged land. Mole drainage has good potential for draining fine-textured soils in southern Alberta, either by itself or in combination with subsurface tube drainage. It is simple and relatively inexpensive to install. Mole drains were installed at 50, 70, and 90 cm depth in a clay loam soil. Three water treatments were used on the soil: not flooded (D), flooded 1 week prior (F1) to installation, and flooded 1 day prior (F2) to installation of the drains. The treatments affected the conditions of the moles, the fracturing of the soil above the moles, and the bulk density of the soil around the moles. The greatest amount of smearing around the perimeter of the moles was in the F2 treatment and the least was in the D treatment. Visible fracturing of the soil above the drains was affected by depth of drain installation as well as by water treatment. In the 50-cm-deep drains, fracturing started at the side of the mole and fanned out upward to the surface. In the 90-cm drains there was minimal fracturing, starting at about the 50-cm depth. The most fracturing was under the D water treatment and the least was under the F2 treatment. The mean bulk density of the soil above the moles was less than below the moles, where it was similar to that of the undisturbed soil, the region of most water entry into subsurface drains. Drag between the bullet and the soil removed segments of the smeared skin, leaving areas of unsmeared soil through which water could easily enter the drains. Thus, water entry into the mole should not be restricted by compaction and smear, regardless of depth of installation or water content of the soil during installation, providing the soil is at 50% field capacity or wetter.

Reclamation of saline land with mole drainage. Mole drains, installed 0.7 m deep, were effectively used to reclaim a saline clay loam soil. Within 5 years the mean electrical conductivity (EC) of the surface 60 cm of soil, in about one-half of the plot area, had been reduced from greater than 8 dS/m to less than 4 dS/m. The mean EC for the plot area at the 0–60 cm and 0–180 cm depths declined in a logarithmic order with time. The salts removed were mostly sodium, calcium, and magnesium sulfates.

Water and climate

Seasonal water quality on the upper Oldman River. Water samples were collected monthly from the upper Oldman River during 1982. In that year, precipitation was 7% below the 82-year average of 407 mm. Because surface runoff from yearly precipitation in the watershed accounts for a dominant portion of the water that fills the Oldman River, the river flow is highly dependent on winter snowpack and spring and fall rains. Thus, forestry management of the upper watershed has a pronounced effect on the water quality of the surface water passing through the system. The construction of a dam on the Oldman River will retain this runoff water and the water quality may have a serious effect on the potential growth of aquatic vegetation in the newly filled storage reservoir.

The concentrations of the various chemical constituents reflected seasonal fluctuations. Soluble salts were highest in the winter–spring period, then dropped to a steady level during the summer and fall–winter periods. Total water hardness appeared highest in the fall–winter period with the specific conductance highest in the winter–spring period. Alkalinity peaked during the fall–winter period. Total phosphates, soluble phosphates, and particulate phosphates were all highest during the summer period owing to the heavy rains in June and July. Nitrates were highest during the winter–spring period. Total solids, total dissolved solids, and silt were low throughout the year because of the heavily forested nature of the upper Oldman River watershed.

Estimation of potential and crop evapotranspiration in southern Alberta chinook region. Crop production on both irrigated and nonirrigated lands in southern Alberta is greatly affected by available soil moisture which is generally influenced by potential evapotranspiration. All methods of measuring or estimating potential evapotranspiration have some limitations and most of them tend to underestimate the potential evapotranspiration in this region if the Chinook wind effect is not accounted for. A model that incorporates this prevailing wind effect was developed, based on the Jensen–Haise approximate energy balance method and 1986 weather data, and tested in 14 fields located in two different areas. A computer program that includes this potential evapotranspiration model and a set of empirical moisture budget accounting equations was developed to compute the soil moisture on a daily basis. The statistical analyses conducted on the measured and calculated soil moisture data indicated that the soil moisture data computed with the modified equation were not significantly different than those obtained from the gravimetric technique. In comparison, the soil moisture data computed with the original Jensen–Haise equation were significantly different than those obtained from the gravimetric technique and those obtained from the modified Jensen–Haise equation. The use of this model for estimating the soil moisture in the chinook-dominated southern Alberta region is highly recommended.

Assessment of methods to estimate soil moisture status. A 20-week simulation of soil moisture in a 135-cm profile of clay loam soil under summerfallow conditions in southern Alberta with adaptations of two common soil moisture models indicated that both gave reasonable estimates of soil moisture status. The more accurate of the two models, the Hayhoe and DeJong model, required laboratory determination of soil physical properties. The SPAW model relied on generalized relationships to approximate the required physical properties. The methods of calculating potential evaporation (PE), the driving function for the models, yielded quite different estimates of PE. However, the actual evaporation values simulated by the models were similar. In both models, soil water evaporation was controlled to a large degree by imposed soil physical characteristics during dry periods. However, under wet conditions when water is more readily available in the top portion of the profile for evaporation, estimates of PE are more critical.

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Research Station
Agassiz, British Columbia

PROFESSIONAL STAFF

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J. Budac, B.Sc., M.Sc., Ph.D. National Research Council of Canada visiting fellow, September 1987–September 1988	Analytical Chemist
Y. Gao, B.Sc. Hebei Academy of Agricultural and Forestry Sciences, Hebei, People's Republic of China, December 1987–November 1988	Soil water assessment

M.-M. Gaye, B.S.A. Agri-food Regional Development Subsidary Agreement	Vegetable season extension

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[1] Seconded from Libraries Division, Corporate Management Branch, 10 August 1987.
[2] Transferred from Melfort Research Station 1 December 1987.
[3] Seconded to Priorities and Strategies Directorate, Ottawa, August 1987–August 1988.
[4] Appointed 23 November 1987.
[5] Appointed to emeritus status, 2 September 1987.
[6] Transferred from Saanichton Research Station 1 April 1987.
[7] Transferred from Saanichton Research Station 1 April 1987.
[8] Transferred from Saanichton Research Station 1 April 1987.
[9] Appointed 16 November 1987.

INTRODUCTION

The Agassiz Research Station has a mandate to conduct research in both plant and animal science.

The Animal Science Section is responsible for research on dairy cattle nutrition, including ruminant mineral biochemistry. The poultry program includes nutrition, physiology, and animal behavior. Although the section serves the livestock industry of British Columbia, it is also recognized nationally and internationally as a centre of excellence.

The Crop Science Section has a broad mandate to undertake research on the management and physiology, postharvest physiology, entomology, and plant pathology of greenhouse and field vegetables, management of small fruits, including kiwifruit, and forage management. These programs are supported by soils research on a wide variety of fertility and soil management problems.

The research feedmill provides opportunities to conduct research in livestock nutrition and has the capability to produce newer, more economic feedstuffs. This is the only research facility of its kind in British Columbia.

Further information regarding the research programs and results achieved may be obtained by requesting copies of the listed publications and other informal reports. Requests should be directed to the Research Station, Research Branch, Agriculture Canada, P.O. Box 1000, Agassiz, B.C. V0M 1A0; Tel. (604) 796-2221.

J.M. Molnar
Director

ANIMAL SCIENCE

Copper and selenium supplementation for ruminants. A commercially available (U.K. only) bolus for the supplementation of copper and selenium to ruminants was evaluated in a large field trial involving 239 cow–calf pairs of mixed beef breeds in the British Columbia interior. Although the bolus was found to be an effective selenium supplement, it was ineffective as a copper supplement and, therefore, could not be recommended for British Columbia.

Selenium stable isotope analysis. By combining inductively coupled plasma mass spectrometry and hydride generation technologies, a very sensitive and precise method of analysis for selenium and selenium stable isotopes was achieved. The new method represents a significant improvement over existing technology and will be an important research tool in cattle nutrition studies.

Abnormal variation in daily milk yield as a criterion of estrus or disease. The use of computers to monitor individual grain consumption and milk yield in dairy herds provides the dairy farmer with another means of identifying changes in a cow's physiological status. The day-to-day variations in the milk yield of 105 lactations were analyzed to determine those portions of the total variation which could be accounted for by yield or changes in environment and management. It was assumed that deviations in the remainder of the variance might be accounted for by estrus or incidence of disease. Initial analysis of the data indicated that difference in yield accounted for a substantial portion of the variation. Further analysis of the data indicated that major management changes, such as onset of the pasture season or environmental changes (extreme cold), accounted for relatively small amounts of the remaining variation in daily milk yield. However, the verification of the onset of estrus or incidence of infection by an increased variation in daily milk yield proved to be impossible.

Silage additives. A series of trials were conducted over the past 3 years to identify ensiling conditions under which different types of additives are effective. It was concluded that wilting of a forage cut at an optimum maturity of approximately 30% dry matter produced a silage that could not be improved by an additive. However, both propionic-based and bacterial-based additives improved the intake and/or digestibility of direct-cut forages. Bacterial-based additives improved the intake of more mature forages wilted under adverse conditions. It was concluded that specific additives have a beneficial influence on the nutritive value of grass silage.

Behavior of chickens prior to death from sudden death syndrome (SDS). A study was made to determine if chickens dying from SDS showed any unusual behavioral characteristics during the 12 h preceding death. Analysis of video recordings revealed no significant differences between SDS chickens and matched controls in the performance of 19 different behavior patterns. It was concluded that there were no consistent behavioral symptoms which could be used to identify SDS chickens prior to death.

Relationship between age, body weight, and season of the year and the incidence of sudden death syndrome (SDS) in male broiler chickens. Data from 23 experiments conducted from July 1982 to June 1987, involving a total of 89 988 chickens from 1 day old to a maximum of 70 days were analyzed. All chickens that died during this time were necropsied and the incidence of SDS noted. SDS mortality ranged from 1.31 to 9.62% among experiments. Death rate from SDS showed a significant increase with body weight. The SDS mortality rate reached a maximum between 21 and 27 days of age. Death from SDS increased to about 21 days of age and remained between 80 and 86 out of 100 000 chickens per day to 39 days of age, with a gradual decline to the end of the observation period (63 days of age), when death from SDS was 54 out of 100 000 per day. Death rate from SDS may be related to the month in which the experiment started, with the highest mortality occurring in January and the lowest in July. The correlations between death rates from SDS and other causes of death were not significant.

Effect of estradiol-17β monopalmitate on the incidence of sudden death syndrome (SDS) in male broiler chickens. Male broiler chickens have an incidence of SDS about three times that of females. One thousand male broiler crossbred chickens were implanted with 15 mg of estradiol-17β monopalmitate at 2 weeks of age; another 1000 chickens served as controls. All chickens that died during the 9-week experiment were necropsied and the incidence of SDS determined. There was no significant difference between treated and control groups in total mortality or mortality attributed to SDS. Treated chickens had higher feed-to-gain ratios and drank more water than controls.

CROP SCIENCE

Trickle chemical irrigation and crop root zone management. A 3-year root zone management experiment on raspberries and green peppers with trickle irrigation, fertilization, and nematicide application has shown that (*1*) the harvesting period of green pepper was extended from 5 weeks to 12 weeks with application of row covers and trickle fertilization, and (*2*) the root-lesion nematode *Pratylenchus penetrans* in the root zone and raspberry feeder roots has been effectively controlled with post-planting nematicide application by means of a trickle irrigation system. Both plant vigor and marketable yield were increased significantly in comparison with check plots.

Kiwifruit production. The results of trials with kiwifruit have led to the establishment of a kiwifruit industry in British Columbia, with its first commercial harvest completed in 1987. The research program obtained background information on plant management, winter protection, and training and pruning of the vines. Yield obtained from 5-year-old plants of the cultivar Hayward was 80 kg of fruit per vine.

An evaluation of nitrogen use in British Columbia agriculture. In an evaluation of nitrogen use in British Columbia a comparison was made of the amount of nitrogen used in various regions of the province with current recommended rates, and the published research upon which the recommendations could be critically assessed was reviewed. The comparison showed that areas of intensive crop production (south coast and Okanagan) were using nitrogen rates generally at or above recommended rates, particularly if manure nitrogen is included. Other areas of the province with more extensive agriculture were using rates considerably below recommended rates. The review revealed that research on nitrogen has been relatively small and diverse, with very little research that included soil nitrogen measurements, resulting in recommendations based on extensive extrapolation and speculation. More research studies, particularly those that include soil nitrogen measurements, are required to refine current recommendations and to instill confidence for reducing or increasing use according to the specific location and activity.

The dynamics of inorganic nitrogen in a Fraser Valley soil with and without spring or fall ammonium nitrate applications. Data from a soil-monitoring study at the Agassiz Research Station, together with historic weather data, was used to determine the leaching potential of nitrate in south coastal British Columbia. There is low potential for leaching during the growing season but very high potential over the winter. This is because of the seasonal distribution of rainfall and potential for evaporation despite relatively high yearly precipitation (650–1650 mm). This shows that nitrogen management methods must be directed toward minimizing residual inorganic nitrogen in the root zone after crop harvest to increase the economics of crop production and to reduce environmental risks due to nitrate pollution of ground water. Also, since essentially all residual soil inorganic nitrogen is lost over the winter, development of soil-analysis-based nitrogen fertilizer recommendations will be dependent on estimating the available nitrogen in the organic matter. The study also showed for the first time that clay fixation of ammonium occurred in this soil and this process should be considered in future nitrogen studies.

Vegetable season extension. Results of trials conducted from 1984 to 1987 on the use of row covers to promote earliness and increase marketable yield of certain vegetables indicate that crops such as zucchini, slicing cucumber, cantaloupe, and bell pepper respond positively. The degree to which earliness can be enhanced varies with the crop and the seasonal climate, but all the crops tested in these trials produced larger and earlier yields when grown under row covers than when left unprotected.

Late production of zucchini. In an attempt to extend the production of zucchini into the fall, row covers were applied in mid-September to plants established in the field on 24 June. Blow fly larvae were introduced periodically to pollinate flowers. Results show that blow flies were not effective in pollinating zucchini flowers and that marketable yields from unprotected plots were greater than those from protected plots because of lack of pollination under row covers.

Response of overwintered cauliflower to nitrogen (N) side dressing. In a field trial at Abbotsford, N was applied as a side dressing at the rates of 0, 100, 200, and 300 kg/ha to two overwintered cultivars, Armado April and Arminda. Results show that both cultivars responded similarly, the 200 kg rate being the optimum with respect to marketable yield and head weight.

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Research Station
Kamloops, British Columbia

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A.L. van Ryswyk, B.S.A., M.S.A., Ph.D.	Soil science

Prince George Experimental Farm

K. Broersma,[3] B.S.A., M.Sc.	Superintendent; Forage agronomy

VISITING SCIENTIST

D.J. Thompson, B.Sc., M.Sc., Ph.D. National Research Council visiting fellow	Grass–legume establishment

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[1] Biologists–research scientists training program, 15 October 1985.
[2] Appointed 1 April 1987.
[3] Appointed 8 October 1987.

INTRODUCTION

The research programs at the Kamloops Range Research Station and the Prince George Experimental Farm are designed to serve the ranchers and managers of the diverse rangelands and farmlands of the southern and central interior of British Columbia. Research is focused on developing and transferring new technology in the fields of range management, plant ecology, poisonous plants, bloat, winterhardiness, forage agronomy, quality of conserved forages, and animal nutrition.

The research station is pleased to announce the appointment of Dr. Priyadarshini Mir as a research scientist, effective 1 April 1987. Dr. Mir will be conducting research in the areas of ruminant nutrition and digestive physiology through investigations into improvement of digestibility and intake of fibrous feeds for ruminants and through determinations of compositional changes in forages during harvest and storage.

Further information on our research activities is available from the Research Station, Research Branch, Agriculture Canada, 3015 Ord Road, Kamloops, B.C. V2B 8A9, Tel. (604) 376-5565; or from the Experimental Farm, R.R. 8, RMD #6, Prince George, B.C. V2N 4M6, Tel. (604) 963-9632.

J.A. Robertson
Director

RESEARCH ACTIVITIES

Recovery of pinegrass, following simulated grazing

During a 10-year study of pinegrass (*Calamagrostis rubescens* Buckl.), the rate of recovery from overgrazing was studied. For four consecutive years, tillers were clipped to heights of 15, 10, and 5 cm to imitate light, moderate, and heavy grazing, respectively. Each year the plants were clipped biweekly from mid-May to mid-September. Clipping to 15 cm removes about 40% of the aboveground growth of pinegrass, whereas clipping to 10 cm removes about 56%, and to 5 cm about 72% of the growth. Unclipped plants were used for comparison. Clipping to 5 cm dramatically decreased the pinegrass stand each year. Clipping to 10 cm produced a moderate decrease, and clipping to 15 cm produced a minor and insignificant reduction in tillers per unit area.

After the 4-year treatment period, recovery of the pinegrass was monitored for 6 years. Using this data, we were able to estimate the time required for complete recovery. Although the reduction in number of tillers following light (15 cm) grazing was not statistically significant, tiller numbers per unit area did increase during the recovery period. On the assumption that the effect was real, it was estimated that a minimum of 7 years would be required for full recovery of pinegrass, following light grazing for 4 years. After 4 years of moderate (10 cm) grazing, the estimated recovery time was 13 years.

Yield and quality of grasses at seven locations

Yield and chemical composition were determined for seven grass species at seven locations throughout the central interior of British Columbia. The seven species were smooth bromegrass (*Bromus inermis* Leysser), crested wheatgrass (*Agropyron desertorum* (Fischer ex link) Schultes), timothy (*Phleum pratense* L.), reed canarygrass (*Phalaris arundinacea* L.), meadow foxtail (*Alopecurus pratensis* L.), creeping red fescue (*Festuca rubra* L.), and intermediate wheatgrass (*Agropyron intermedium* (Host) Beauv.). The locations included two sites at Smithers and one each at Grassy Plains, Vanderhoof, Prince George, McBride, and Williams Lake. At each site and for each grass, dry matter yield, in vivo digestibility, crude protein, phosphorus, calcium, potassium, magnesium, manganese, copper, and zinc were determined. Also calculated were digestible dry matter yield, crude protein yield, and the calcium-to-phosphorus ratio.

The yields of the grasses at the seven different locations varied with the amount of precipitation available, temperature, and soil conditions. There were location and species interactions because of varying soil and climatic conditions. The highest average yield for all sites was obtained with reed canarygrass, but it had the lowest percentage of digestible dry matter. Intermediate wheatgrass performed well and had the second highest yields but had a low crude protein content and was not very digestible. The yields of meadow foxtail and crested wheatgrass were the lowest.

Phosphorus concentrations were highest in meadow foxtail, whereas the wheat grasses contained the lowest percentages of phosphorus. Creeping red fescue accumulated a higher concentration of calcium than the other grass species in the test. The micro-nutrient levels also varied with grass species. The wheat grasses tended to be low in magnesium, manganese, copper, and zinc. Reed canarygrass accumulated higher amounts of magnesium, and creeping red fescue had greater concentrations of copper and zinc than those found in other species.

Alfalfa yield and irrigation interval

Reducing the irrigation interval from 13 to 9 days increased alfalfa (*Medicago sativa* L.) yields from 3.0 to 4.5 t/ha for each of the second and third cuts (mid-June through August). The proportion of days during which available soil water storage capacity (ASWSC) exceeded 50% was inversely related to irrigation interval, increasing from 40 to 95% concurrently with the reduction in intervals between irrigations. No yield increase was noted for the first growth period prior to mid-June over the same range of ASWSC. The substantial yield increase for the second and third growth periods can be partly attributed to higher evapotranspiration resulting from hot dry air moving on to the crop from adjacent dry rangeland, compared to that for the first growth period when air temperatures were lower and rangeland was still moist from winter precipitation.

An average irrigation interval of 9 days resulted in a 50% or greater ASWSC occurring on 95% of the days during the second and third growth periods. Estimates of climatic moisture deficit averaged for the 3 years of the study indicate that the weather was drier than that for the 30-year long-term average. An irrigation interval of 11 days was derived from the British Columbia irrigation manual (1980) for the Kamloops site. This interval would likely achieve near-maximum alfalfa yields for years with average climatic moisture deficits.

Timber milk-vetch poisoning

The growth and miserotoxin content of timber milk-vetch (*Astragalus miser* Dougl. var. *serotinus* (Gray) Barneby) were examined in clipping trials at two rangeland sites in southern British Columbia during 1983 and 1986. Growth was determined by measuring the freeze-dried weight of each plant and miserotoxin levels were estimated by a rapid screening method that simplified sample preparation for spectrophotometric determination. In both years and at both sites, growth and toxicity were substantially reduced in response to clipping early in the spring. In comparison to untreated plants, the aboveground biomass of clipped plants was reduced by at least 50% during a 6-week period of regrowth. A similar reduction was also observed in the miserotoxin content of clipped plants. The results indicate that early grazing may reduce the potential hazard of timber milk-vetch to livestock.

Larkspur poisoning

The neurotoxic diterpenoid alkaloid, methyllycaconitine (MLA), was isolated from low larkspur (*Delphinium nuttallianum* G. Pritz.), and a method was developed utilizing ion-pair high-performance liquid chromatography (HPLC) to determine its concentration in freeze-dried plant samples.

A survey of the levels of MLA in low larkspur was then conducted at four diverse rangeland sites in southern British Columbia. Freeze-dried plant samples representing three stages of growth over two growing seasons were analyzed for MLA by the new HPLC method. Significant differences were found among experimental sites ($P < 0.001$), with higher levels of MLA (>0.2% on a dry weight basis) being associated with sites at higher elevations (900–975 m). At one site, an exceptional level of MLA (>0.3%) was observed during the flower bud stage of growth, but in general the alkaloid levels remained fairly constant with advancing stages of growth. Measurement of the MLA concentrations in different plant parts revealed that reproductive parts contained higher levels of MLA than vegetative parts, and this may well explain the increased toxicity of the upper portions of the plant.

Pasture bloat in cattle

Chlorophyll levels in rumen contents from the dorsal and ventral sacs were examined before alfalfa ingestion to determine the relationship of chloroplast particles to the onset of pasture bloat in cattle. Chlorophyll concentrations were significantly higher in cattle that subsequently bloated than in those that did not. The higher levels were observed in both the liquid and solid phases of rumen contents from cattle predisposed to bloat, but the liquid phase showed a greater increase. Chlorophyll levels were uniformly distributed in the rumen with little or no difference between samples obtained from the ventral and dorsal sacs. In agreement with previous results, animals predisposed to bloat showed higher rates of gas production and greater buoyancy of particulate matter in prefeeding rumen fluid. The results suggest that chloroplast particles in the rumen have a slower rate of clearance in bloating animals than in non-bloating ones.

Mineral evaluation from body hair

Hair sampled from the forehead, neck, shoulder, and flank of 42 Hereford cows was cleaned, dried, and analyzed for nitrogen, phosphorus, calcium, magnesium, copper, zinc, and iron. Hair nitrogen content was the same at all body locations, ranging from 13.1 to 13.4% of dry matter. Phosphorus, calcium, magnesium, copper, zinc, and iron concentrations in hair were generally lower in white hair on the head than in colored hair from other sites. There were also differences in the mineral content of colored hair clipped from different body sites.

It may be possible to detect mineral variance from normal values by analyzing colored hair from specific body sites. Neck hair may be best for measuring phosphorus, copper, zinc, iron, and nitrogen; shoulder hair for measuring calcium; and flank hair for measuring magnesium.

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Research Station Summerland, British Columbia

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INTRODUCTION

The Summerland Research Station, located in the Okanagan Valley of southern interior British Columbia, conducts research concerned primarily with solving problems of production and utilization of tree fruits and grapes, with the objectives of increasing production efficiency, reducing production costs, and providing high-quality products to consumers. Studies are also done at substations located at Kelowna to the north and Creston to the east and in growers' orchards and vineyards in the Okanagan, Similkameen, and Creston valleys. Cooperative involvements in research with food processing companies extend Canada-wide.

Dr. P. Parchomchuk returned from educational leave in California and assumed responsibility for new irrigation research. A VAX 730 computer was installed and J. Wild was appointed as Computer Systems Manager. Work with the electron microscope was initiated, under the supervision of L. Veto, an electron microscope technician. Dr. A.T. Paulson resigned from the Food Processing Section to assume a position at the Technical University of Nova Scotia. Overseas travel of station scientists under joint funding including industry, the Washington State Tree Fruit Research Commission, and the technical inflow program (TIP) of External Affairs has increased international contacts in Europe, Japan, and China in the research areas of tree fruit breeding, tree fruit replanting problems, viruses in tree fruits, and management of more intensive tree fruit plantings.

This report contains brief statements of some major achievements attained at this establishment in 1987. Further information may be obtained from publications listed at the end of this report or from individual scientists. Requests for information or reprints should be addressed to the Research Station, Research Branch, Agriculture Canada, Summerland, B.C. VOH 1Z0; Tel. (604) 494-7711.

D.M. Bowden
Director

ENTOMOLOGY–PLANT PATHOLOGY

Grape thrips monitoring and biology

Monitoring populations of the grape thrips, *Drepanothrips reuteri* Uzel, a new pest of grapes in British Columbia, in five commercial vineyards by using a beating tray confirmed the occurrence of three summer broods of this pest. Overwintered virgin females were present on the developing grape foliage in late May and early June. The emergence of the first, second, and third summer generations peaked 4, 8, and 13 weeks later about 30 June, 29 July, and 2 September, respectively, at Summerland, Okanagan Falls, and Osoyoos. These dates are similar to the population peaks that occurred in 1986. Visual evidence of stem and leaf feeding injury was first detected 8 July, 1 week after peak emergence of the first brood adults. Chemical control was required in three vineyards when population levels of the first brood reached averages of 17.8, 19.2, and 35.4 nymphs and adults per sample, respectively. No control treatment was required in two vineyards that had levels of 1.6 and 1.8 thrips per sample.

Use of pressure infiltration as an inoculation technique for postharvest studies on fungal pathogens of pome fruits

The pressure infiltration method permits large quantities of fruit to be inoculated at one time and can be useful in determining the efficacy of current and new fungicides. A 1125-L retort cooker connected to an air supply (620 kPa) was used for the pressure infiltration of inocula. Incidence of rots on apples and pears by inoculation under pressure was dependent upon fruit cultivar and fungal species. Values of 75%, or more, rotted fruits were obtained by this method compared to 100% by the puncture and dip method. Inoculation by means of pressure infiltration is perhaps more representative of natural infections than is the puncture method. Addition of calcium chloride or fungicide to the inoculum either eliminated or significantly reduced the incidence of rots. Pressure infiltration disrupts lenticels and thus allows an avenue of entry for infective propagula.

Evaluation of resistance to *Phytophthora cactorum* in apple rootstock cultivars

An excised shoot assay was used to evaluate resistance to crown rot and root rot caused by *Phytophthora cactorum* (Leb. & Cohn) Schroeter, in several apple (*Malus domestica* Borkh.) rootstock cultivars, using relative lesion length as a measure of resistance. To determine the best season to assess crown rot resistance, three cultivars of known field resistance, M.26 (moderately resistant), MM.111 (moderately susceptible), and MM.106 (susceptible) were tested monthly for 1 year. Differences in degree of resistance between the three cultivars were most pronounced during the period of February–June and again in November. When 27 apple rootstock cultivars were tested quarterly, January, April, July, and October, good separation of the known standards was achieved only for the April sample period. Based on the mean rating for April, October, and January, the cultivars Polish (P.) 16, Jork 9, P.2, Ottawa 3, M.9, M.26, P.18, P.22, P.1, and M.4 were significantly more resistant than the most field susceptible rootstock, MM.106. None were significantly more resistant than M.9 and M.4, the most field resistant standards. In both assays, all the cultivars were equally susceptible during the July sample period when vegetative growth is most active.

Monitoring fruittree leafroller resistance to azinphos-methyl

It is necessary to recognize where azinphos-methyl resistance is responsible for problems in fruittree leafroller control in order to employ correct management strategies. A modified bioassay technique of detecting insecticide resistance appears to offer a simple method to survey orchards for this control problem. Pheromone-baited traps were placed in a block of orchards where azinphos-methyl resistance had been confirmed in the fruittree leafroller population and in 20 surrounding orchard sites. Topical applications of azinphos-methyl were made to the abdomens of adult moths caught in the traps and mortality was assessed 24 h posttreatment. In both years of the study the highest LC50s were obtained in the orchards believed to support resistant fruittree leafroller populations and the lowest LC50s were obtained from the peripheral orchards.

Fumigation to kill codling moth eggs on export Van cherries

Another variety of cherries may soon be exported to Japan. To meet quarantine requirements a protocol has been developed to kill codling moth eggs on fresh Van cherries. When 50 000 eggs on cherries were fumigated with methyl bromide at 64 g/m^3 for 2.5 h at 6°C, all eggs died. This low fumigation temperature has been requested by industry to assist in maintaining a high-quality product. It is expected that this protocol will satisfy the strict Japanese quarantine requirements regarding the codling moth, permitting a second variety of cherries to be exported after fumigation at a lower temperature than previously permitted.

Screening biological agents for control of apple replant disease

Apple replant disease (ARD) relates to the poor growth of fruit trees planted in old apple or pear orchard sites. This disease suppresses growth and yield of both pome and stone fruits in British Columbia.

Seventy-six species of fungi were isolated from soils of orchards with expression of ARD. Four of these species caused marked suppression of growth of McIntosh apple seedlings when grown in pasteurized field soils back-inoculated with the isolated fungi. In vitro, 21 isolates of the bacterium *Bacillus subtilis* produced inhibition zones against 20 out of the 76 ARD fungi grown on potato dextrose agar. Isolate Bact 1 showed significant antagonism against 17 of the ARD fungi on potato dextrose agar and also increased apple seedling growth in pasteurized and fertilized soil in greenhouse pot tests. Isolate EBW4 increased apple seedling height in pasteurized and fertilized soil in greenhouse pot tests, but it did not show antagonism against most of the ARD fungi. Twelve of the *B. subtilis* isolates stunted the growth of apple seedlings, but fertilization of both pasteurized and unpasteurized soil with NPK 11-55-0 suppressed the stunting effect. Under field conditions, both the Bact 1 and EBW4 isolates increased the shoot growth in unfertilized and unpasteurized ARD soil. The results indicate that these isolates offer protection to newly planted apple trees against ARD.

Control of codling moth in apple orchards with synthetic sex pheromone-based mating disruption

Three synthetic components of the codling moth pheromone blend (EE-8-10 dodecadien-1-ol, tetradecanol, and dodecanol) were released at an hourly rate, which varied with temperature, of between 4 and 32 mg/ha into two commercial orchards. The two orchards differed in terms of location, isolation from other orchards, and relative abundance of codling moths (based on the previous year's pheromone trap data). Significantly fewer male codling moths were captured in either synthetic sex-pheromone or live virgin female baited traps in the pheromone treated blocks of both orchards. There were significantly fewer codling moth-damaged apples in the pheromone-treated blocks of both orchards compared to the untreated blocks.

FOOD PROCESSING

Microstructure of apple juice particulates

The microstructure of apple juice from fresh and stored Spartan apples processed with and without an enzyme digestion and with and without blanching was examined by thin-sectioning and negative-staining transmission electron microscopy. Particles were categorized as granules (3.4–53.6 nm), spheres (20.1–544.4 nm), and aggregates (20.1–2518.9 nm). Enzyme treatment with polygalacturonase significantly decreased granule size ($P < 0.05$). Storage of apples significantly decreased aggregate length ($P < 0.05$) and also resulted in a web-like appearance in the particulates of negatively stained preparations of juice particulate. The web-like aspect of the particulate was removed either through enzyme treatment with polygalacturonase or by blanching. In addition, blanching appeared to cause the disintegration and solubilization of large structures found in juice from unenzymed, unblanched puree to form smaller, more numerous structures.

Vacuum-assisted pressing of fruit

Pilot-scale testing of a new press design has shown greatly increased throughputs of raw materials. Depending on other factors such as fruit quality and acceptable juice characteristics, the rate of production of apple juice can be virtually doubled. A Vetter 0.5 screw press was employed but it is believed that the principle can be widely applied. The actual expression section of the Vetter press was already a sealed chamber to allow gas flushing, but by applying a vacuum to the chamber it was possible to achieve improvement in performance. When operated at optimum conditions, yields of 75–82% (w/w) were achieved, depending on fruit quality and whether or not press aid was employed. When a moderate vacuum was applied, yield was shown to increase by 2–3%, but the rate of production of juice was virtually doubled. Operating conditions could be altered from the optimum to increase output by increasing screw speed and using very high vacuums, but juice quality was adversely affected. Even though production rates were increased and the differences between standard and experimental systems were reduced, suspended solids in the juice was a serious offsetting factor. This finding, when applied commercially, should result in significant improvements in production efficiency.

POMOLOGY AND VITICULTURE

Influence of orchard floor management on vole and pocket gopher populations and damage in apple orchards

Removal of all vegetation with herbicides over the total orchard floor or only in tree rows significantly reduced montane vole (*Microtus montanus* Peale), meadow vole (*M. pennsylvanicus* Ord), and northern pocket gopher (*Thomomys talpoides* Richardson) populations and damage. Herbicide treatments in four test orchards were done during May, July, and September 1983–1985. Average overwinter abundance of voles was reduced 53–99% on treatment areas. Several vole populations went to extinction in the 3rd year of herbicide treatment. Incidence of tree damage was 40.6 and 9.6%, with feeding intensities of 17.2 and 0.4 cm^2 of bark and tissues per tree removed on control and treatment blocks, respectively, during a peak year in abundance of voles. Pocket gopher populations and damage were significantly lower in treatment than control blocks. Use of herbicides to control orchard floor vegetation is an effective means of rodent damage control.

Sumac, a summer apple

Sumac originated as an open pollinated seedling of New Jersey seedling 654014 and was propagated at Summerland by Dr. C. Lapins as seedling 9F-22-42. It is named and introduced after 10 years of comparative testing at Summerland. In addition, a number of commercial growers have established small plantings that have contributed information on the performance of Sumac when managed commercially.

The fruit of Sumac are 80–100% red and have a shape resembling Spartan. The taste of Sumac is much sweeter than other apples in its season. At Summerland, the first fruits mature about 5 August in most years, approximately 5 days before Vista Bella and 10 days after Lambert cherry. The picking duration is about 10 days. Sumac is outstanding for combining early maturity and attractive appearance with sweet, good taste.

The growth habit of Sumac is vigorous but spur production is abundant and it is considered to be a semi-spur type. Trees at Summerland have fruited consistently, with little tendency to biannual bearing. Bloom time is early, before McIntosh. Sumac is susceptible to mildew but no more so than other early varieties.

Sumac should be of special interest to growers who need to diversify their fruit crops. It has been particularly attractive to growers selling to fruit stand merchants or to independent shippers, and market response to date has been very favorable. The shelf life of Sumac is short; however, commercial experience has demonstrated it to be satisfactory provided fruit are stored refrigerated and retailers understand the potential for rapid ripening during hot summer weather.

Sylvia sweet cherry

Sylvia cherry, formerly seedling 4C-17-31, resulted from a cross of Compact Lambert × Van made in 1969 at Summerland. It was incorporated into variety test plots in 1971 at Summerland and, since then, has been distributed to several countries for cooperative testing. The fruit of Sylvia are medium to large size, approximately 2.8 cm in diameter. Firmness is equivalent to or better than Lambert, and Sylvia responds very favorably to gibberellic acid. Postharvest durability tests indicate that Sylvia is equivalent to Lambert in resistance to pitting. Fruit mature 4–5 days before Lambert or slightly after Stella. Stems are medium length and very thick, and they are outstanding for remaining green in storage. Flavor is very good. The fruit of Sylvia is outstanding for resistance to splitting caused by rain. In years when fruit in nearby Lambert trees had 40% splitting, Sylvia fruit had less than 3% splitting.

The tree of Sylvia is excellent for compact and spur-type growth habit. Its growth habit is similar to Compact Stella; however, its branches are more spreading, making the tree height of Sylvia less than that of Compact Stella. Fruit distribution along branches is excellent, with little tendency for fruiting to occur in clusters. Cooperators in Spain have reported that because of the short internode length, which results in high leaf density, Sylvia is very resistant to sunburning of fruit. Leaves also resist damage from hot, dry winds better than other varieties. Sylvia has proved to be an outstanding variety for high-density plantings and is particularly suited for this purpose. Bloom time is very late, the same as Sam, and it is not self-fertile.

Sylvia should be of particular interest to growers interested in high-density cherry plantings and to other growers interested in a mid-season variety with good quality and outstanding resistance to splitting.

Quality of Spartlett pear

The Spartlett pear originated as a chance seedling several years ago in Michigan. It resembles a Bartlett pear but is considerably larger, averaging 300 g in weight, but fruit of 450 g are not uncommon. The pears are harvested in the 1st week of September and can be kept to February in refrigerated air storage or for 7 months in controlled-atmosphere storage (2% CO_2 + 2% O_2 at 0°C). Ripened fruit are golden yellow and often have a red blush. Texture is smooth, grittiness is moderate, flavor is somewhat tangy, and aroma is subtle but pleasant. Scuffing is not as prevalent as in Bartlett, and core breakdown appears after 10 days at 20°C. Extended storage in air can lead to senescent scald, a disorder which prevents ripening of the fruit and causes the skin to turn brown.

Maturity of spur and standard McIntosh apples

Spur (Macspur, Starkspur, Dewar, and Morspur) and standard McIntosh apples grown at the research station were harvested at weekly intervals over a 4–6-week period during the years 1984–1987. Factors evaluated at each harvest were firmness, percentage of red skin color, soluble solids, acidity, starch index, size, and core ethylene content. Onset of the climacteric, the ripening phase, is indicated by core ethylene values of 0.5 ppm, or more. No difference in core ethylene content was observed between spur and standard McIntosh, but the spur strains showed earlier development of red skin color. Firmness values were lower in the spur strains than in standard McIntosh for each harvest period over the 4 years. It is apparent that the lower firmness values of spur strains of McIntosh relative to standard McIntosh are caused by factors other than differences in the rate of maturation among the strains.

SOILS–AGRICULTURAL ENGINEERING

Effects of ground covers on soil water stress under irrigation

One of the hypotheses that might explain the large yield and growth responses of grapes treated with plastic mulch compared to those treated with herbicide or grass cover crop, measured over several years, is that soil water contents would be different under the three ground treatments. Data from 1987 soil water samplings reject that hypothesis.

On 20 August 1987, soil water contents in the top 30 cm were 11.6, 11.5, and 12.5% for grass, herbicide, and plastic mulch treatments, respectively, with trickle irrigation applying water at normal rates for the Okanagan during ongoing dry warm weather. These percentages convert to soil water suctions of 29, 29, and 26 kPa, approximating the upper limit of available water. These soil water suctions are close to optimum for the grapevines and many other crops. On 29 September 1987, after irrigation had been stopped inadvertently for several days, soil water percentages had dropped to 4.1, 3.8, and 4.9 for grass, herbicide, and plastic mulch treatments, respectively. These percentages convert to 1500 kPa, or the wilting point of the soil, but again they did not differ from one another.

The conclusions from these data are (*1*) that trickle irrigation with its inherent limited soil-stored water should not be shut down, even relatively late in the season, while water use is still significant, and (*2*) that differences in soil water content, either low or high, were not sufficient to support the hypothesis. Soil water stress was not different under the three treatments.

Steam sterilization of soil

A 60-cm diameter tractor-mounted auger has been developed for simultaneously digging and pasteurizing tree-planting holes in orchards that have apple tree replant disease. Steam from a portable boiler is emitted from the auger head as it turns, intimately mixing with the soil to give a uniformly heated cylinder 60 cm in diameter by 60 cm deep. Trees planted at sites steamed to 80°C grew 70% more than the check trees, based on trunk diameters, during the 1st year. Trees at sites steamed to 90°C grew 120% more than checks, whereas those at sites steamed to 80°C, plus 11-55-0 fertilizer mixed in at 150 g per tree hole grew 123% more than checks. The improvement of 90°C steaming over 80°C steaming implies the presence of a pathogenic factor in retarding young trees and that pasteurization was not complete at the lower temperature. The improvement gained by adding the 11-55-0 fertilizer to the 80°C-temperature soil supports conclusions from other research that there is also a phosphorus nutritional factor involved with apple replant disease. Further experiments using a new boiler are planned for 1988 and it is hoped that the treatment time will be reduced to 1–2 min per site.

Measurement of plant-available zinc in British Columbia apple orchards

Zinc (Zn) availability in 20 southern British Columbia apple orchards was examined in the greenhouse. Zn concentration and uptake in navy beans were measured and compared with soil Zn extracted by DTPA, 0.10 *M* HCl, 0.05 *M* HCl + 0.125 *M* H_2SO_4, and $MgCl_2$ at three concentrations (0.25, 0.50, and 1.0 *M*). Available Zn varied greatly among the soils as measured by the soil tests and by plant Zn concentration and uptake. All $MgCl_2$ Zn extracts and plant Zn measures were significantly negatively correlated with soil pH. It is suggested that increased Zn availability with decreased pH was due to a decrease in the amount of specifically absorbed Zn. Of the seven soil extractants used, 0.25 *M* $MgCl_2$ (1:2

soil-to-extractant ratio), Zn was most closely related to plant Zn uptake and concentration ($r = 0.89$; $P < 0.01$ in both cases). This study is being extended to the field where soil Zn extracted by 0.25 M $MgCl_2$ or DTPA and tree leaf Zn are under comparison for detecting Zn deficiency in 40 commercial apple orchards.

NPK fertilization of Foch grapes

Irrigated French–American hybrid Foch grapes planted in 1979 on a sandy loam soil were fertilized annually in narrow in-row strips at the following rates: N at 50, 150, and 300 kg/ha; P at 0 and 90 kg/ha; and K at 0 and 500 kg/ha. Each rate combined with the others to form 12 NPK treatments for the period 1980–1985. Petiole N, P, and K concentrations were increased by their respective fertilizer additions. Fertilization with N consistently increased cluster weight and yield in two of the four harvests, although petiole Ca, Mg, and Zn were decreased at the 150- and 300-kg rates of N fertilization. Yield was increased in the first fruiting year by P fertilization, although subsequent yield and petiole Ca, Mg, and Zn were unaffected. No yield response to K fertilization occurred, but petiole Mg was decreased in all 5 years and petiole Ca was decreased in 3 years, as a consequence of K fertilization. In general, soluble solids and titratable acidity in the fruit were not consistently affected by NPK fertilization, although juice pH was increased in 2 of 3 years at the highest rates of N and K fertilization and in 1 year at the highest rate of P fertilization.

Seasonal variation of leaf Zn

Delicious, Golden Delicious, Spartan, and McIntosh apple orchards with low leaf Zn concentrations, typical of many orchards in British Columbia, but with otherwise adequate nutrition were monitored for leaf Zn concentration throughout the 1983–1985 growing season. Despite routine applications of dormant Zn to these apple trees, mid-terminal leaf Zn concentrations had declined from relatively high values in May to values near or below the commonly accepted deficiency concentration by the standard leaf sampling time in late June or early July. This decline was judged likely to occur in many local orchards. Further research is in progress to investigate the application of Zn at other times of the year and to assess the reliability of leaf Zn concentrations as a measure of inadequate Zn nutrition.

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INTRODUCTION

This is the 25th annual report of the Vancouver Research Station in which we describe some of the research being done. These activities will reflect our role as the national centre for plant virus research, and our strong involvement in biotechnology as applied to crop health and protection. Our second important program, integrated pest management, is also reported here. During the next few years a number of our senior research scientists will retire. The resulting shifts in emphasis of our research programs by replacement staff will be interesting, although still within the general scope and mandates that we have traditionally maintained.

Further details of research, or reprints of this report and the publications listed can be obtained from the individual scientists or from the Research Station, Agriculture Canada, 6660 N.W. Marine Drive, Vancouver, B.C. V6T 1X2; Tel. (604) 224-4355.

M. Weintraub
Director

VIRUS CHEMISTRY AND PHYSIOLOGY

Biotechnology

A *potato spindle tuber viroid* (PSTV) probe of 350 bases was prepared and used to detect picogram quantities of viroids by a simplified, improved, dot blot, hybridization technique in crude potato and tomato extracts. Optimum conditions for certification of PSTV-free potato plants were established, involving formamide concentration, washing stringencies, exposure time during autoradiography, and method of probe radiolabeling. By using the technique 10 pg of purified PSTV in water and 50 pg of purified PSTV added to healthy plant extract were detected. Hybridization signals were detected from as little as 0.075 mg of infected plant tissue.

Double-stranded cDNA copies of RNA-1 and RNA-2 of tomato ringspot virus were cloned into the vector pUC-9. Comparison of restriction enzyme maps of eight clones indicated that 1.9 kb (kilobases) at the 3' termini of RNA-1 and RNA-2 were similar. Five of these clones were used in northern hybridization analyses and found to contain sequences either unique to RNA-1 or RNA-2 or common to RNA-1 and RNA-2. Southern blot analyses, using clones derived from RNA-1 and RNA-2, confirmed that there is a 1.9-kb nucleotide sequence homology at the 3' termini. A sequence homology of this magnitude has not been reported previously for other plant viruses with multipartite single-stranded RNA genomes.

Double-stranded cDNA to melon necrotic spot virus (MNSV) RNA was prepared and cloned. Restriction endonuclease analyses of two of the clones indicated that together they represented at least 95% of the genome. The two clones were used as probes in nucleic acid hybridization analyses. No hybridization was detected between these probes and either carnation mottle virus or tobacco necrosis virus, although the electrophoresis patterns of the dsRNAs of the three viruses are similar.

Physical, chemical, and serological properties of viruses in vitro

The electrophoretic patterns of dsRNA species isolated from cucumber plants infected with cucumber necrosis virus (CNV) and from *Nicotiana clevelandii* plants infected with tomato bushy stunt virus (TBSV) were almost identical and differed greatly from the electrophoretic patterns of dsRNA species isolated from tobacco plants infected with tobacco necrosis virus (TNV). Hybridization with cloned cDNA of CNV showed that there was extensive homology between the nucleic acids of CNV and TBSV but not between those of CNV and TNV. Gel diffusion tests and ELISAs showed no serological relationship between CNV and five tombusviruses.

Virus infections

Mixed infections of the cowpea (Cp) strain of southern bean mosaic virus (SBMV) and sunn-hemp mosaic virus (SHMV), a virus belonging to the tobamovirus group, indicated that SBMV-Cp replicated and spread from cell to cell in inoculated leaves of the bean cultivars

Pinto and Bountiful, following co-inoculation with SHMV. In single infection SBMV-Cp apparently does not infect bean.

Biological properties

Tomato bushy stunt virus (TBSV)-infected *Nicotiana clevelandii* plants showed some cross-protection against infection by cucumber necrosis virus (CNV) but not against infection by carnation ringspot virus. This observation and the earlier mentioned similarity in the electrophoretic patterns of dsRNA from TBSV and CNV would indicate that the latter should be classified as a tombusvirus.

Turnip mosaic virus, cucumber mosaic virus, and ribgrass mosaic virus, all of which cause serious disease in vegetable crops, were isolated from *Hesperis matronalis* in British Columbia. Because it is a perennial plant it can provide a continuous source of infection over several growing seasons.

Ultrastructual responses to virus infections

Cytopathological studies in *Chenopodium murale* infected with an unusual alfalfa virus isolated in Europe did not demonstrate any virus-like particles, despite the fact that the virus induced three specific dsRNAs in infected tissue and was easily transmitted mechanically and by seed in *C. murale*.

Virus transmission by seed and pollen

Pepper mild mottle virus (PMMV), reported in Canada for the first time in 1985 in European cultivars growing at Richmond, B.C., was directly isolated from seed imported from Europe. The virus, which is distantly related to tobacco mosaic virus (TMV), infects all known cultivars resistant to TMV, causing severe deformation of pepper fruits.

Little cherry disease (LCD)

A very sensitive serologically specific electron microscope detection method for LCD-associated virus-like particles (VLP) in leafdips was developed, using gold-labeled, secondary rabbit anti-mouse antibodies. With this method VLP were detected in commercial, agar-rooted explants from certified virus-free Mazzard F12/1 cherry.

Electron microscopic examination of embedded leaf samples, collected in three consecutive growing seasons from old cherry trees growing in an isolated valley in British Columbia outside the LCD control area, revealed that the three LCD-associated cellular inclusions were present in eight of 19 trees examined. However, LCD-associated VLP were isolated from all 19 trees. In at least three trees these VLP were not restricted to the phloem tissue. Bioassay showed that the non-phloem VLP did not represent apple chlorotic leaf spot virus.

Nine specimens of sweet cherry cultivar Compact Stella that were propagated at the Western Washington Research and Extension Center, Mount Vernon, USA, and which represent three trees in each of three classes of growth habit (compact, semidwarf, and reverted) were analyzed for LCD. Leaf samples of all three trees in the compact class and of one tree in the semidwarf class showed two of the three characteristic disease-associated inclusions. None of the trees in the reverted class showed evidence of LCD.

PLANT PATHOLOGY

Nematology

Grapes. A survey of vineyards in the Okanagan and Similkameen valleys was completed. Two new species of *Xiphinema* were described, and their potential as vectors of TRSV (tomato ringspot virus) and tobacco ringspot virus from weeds to weeds or from weeds to grape is investigated. The most prevalent species, *Xiphinema bricolensis*, was able to transmit TRSV from cucumber to cucumber.

Raspberry. Tarped fumigation coupled with solarization to control root-lesion nematode is being investigated. Nematode density dynamics in fallow plots was followed through weekly and biweekly sampling, depending on the treatments. The root-lesion nematode density decreased by 32% when soil temperature reached above 40°C at 5 cm deep where a plastic tarp covered the ground for 6 weeks (21 July to 2 September). The fumigant Vapam applied at 350 L/ha caused an 80% reduction, and when applied with the tarp it caused an 88% reduction. Vapam applied on tarped plots at 905 L/ha reduced the nematode population by 99%.

Bacteriology

To quantify populations of *Corynebacterium sepedonicum* in potato, microscope slide preparations were stained for immunofluorescence on multiwell slides with a specific monoclonal antibody. Bacterial populations were then estimated as immunofluorescence units (IFU) per millilitre from cell counts made with an automated microscope system. Estimates of cell concentrations at different dilutions of a sample gave consistent results over a wide range of cell populations. One of three numerical estimators based on the logarithm of mean counts at several dilutions had the smallest variance and was used to determine relative populations.

By this procedure, the population of *C. sepedonicum* in field-grown potato plants was monitored throughout the growing season. Fresh basal stem tissue populations of 10^3 IFU/g were detected soon after plant emergence. Bacterial numbers increased logarithmically to 10^{11} IFU/g 13 weeks after planting, at which time foliage symptoms were first expressed. During subsequent weeks, severity of symptoms increased but further increase in the bacterial population was not detected.

A new monoclonal antibody was produced to *C. sepedonicum* extracellular polysaccharide and was useful in ELISA (enzyme-linked immunosorbent assay), immunodiffusion, and latex agglutination. Because it was specific for an extracellular, soluble antigen, the monoclonal could not be used in immunofluorescence. In ELISA it reacted with all strains of *C. sepedonicum* tested but not with other plant pathogenic corynebacteria. It did, however, react with one of 12 unidentified bacteria isolated previously from potato. ELISA on infected tubers was highly sensitive, giving a positive reaction at greater than 10^6 dilution of tissue extract.

Fungal pathology

Polyclonal and monoclonal antibodies were produced to the cellular proteins of various fungal species associated with red raspberry root rot. The *Phytophthora* and *Rhizoctonia* polyclonal antibodies were genus-specific, the *Pythium* antiserum reacted with both *Pythium* and *Phytophthora*, and the *Fusarium* and *Verticillium* antisera were active against each other but not with any of the other genera tested. Monoclonal antibodies from *Phytophthora erythroseptica* and *P. fragariae* were active against each other and *P. megasperma*, but they were not active against *P. cactorum*, *P. cambivora*, *P. cinnamomi*, and *P. megasperma* var. *megasperma*. None of the monoclonal antibodies was species-specific.

Seedlings from 12 collections of *Rubus strigosus*, the North American red raspberry, were screened for resistance to the raspberry root rot causal organism *Phytophthora erythroseptica*. High levels of resistance were found in 11 of the collections, all from British Columbia. Seedlings of the remaining collection, which came from North Carolina, were mostly susceptible. This is surprising because the collection was made in a region from which resistant *R. strigosus* seedlings had previously been found. Seedlings from cultivar-type crosses were all highly susceptible. The resistant *Rubus strigosus* seedlings are now being propagated and some will subsequently be used in the breeding program.

Virology

An antiserum specific for blueberry scorch carlavirus (BSCV) was developed and used in ELISA to conduct a survey for this virus in the Pacific Northwest. During the summer of 1987 about 5000 blueberry plants were assayed for this virus. The virus was restricted to the Puyallup Valley. There were blueberry fields throughout the Pacific Northwest that exhibited scorch-like symptoms. After some initial electron microscopy it appears that there are two viruses that are causing scorch-like symptoms. There are some subtle differences in the symptoms and we are now attempting to develop an antiserum for this second virus, which occurs in British Columbia, Washington, and Oregon and which may be similar to a disease described in New Jersey.

Yield data of Pemberton blueberries infected with BSCV were taken during the summer. Plants infected for 1, 2, and 3 years had a 36%, 54%, and 86% reduction in yield, respectively. Varieties tolerant to this virus were identified as well as varieties that exhibit leaf symptoms but not flower symptoms.

Monoclonal antibodies (mabs) that react with PLRV (potato leaf roll virus) and soybean dwarf virus as well as mabs specific for each of these viruses were developed. Mabs that react with both BWYV (beet western yellows virus) and the RPV strain of barley dwarf virus and some specific for BWYV were also obtained. Mabs specific for other luteoviruses are being developed in an attempt to clarify the taxonomy of this group of plant viruses. Since there are considerable serological relationships between many of the luteoviruses, by using this approach we should be able to develop antibodies that will detect strawberry mild yellow edge virus, a luteovirus. PLRV RNA has also been cloned into a bacterial plasmid and over 95% of the genome is represented in four of the clones that were obtained. These clones will be used to study the possibility of developing a broad spectrum cDNA hybridization probe that will detect most luteoviruses.

Small fruit breeding

Raspberry. The two new cultivars, Chilliwack and Comox, performed well in 1987 and demand for planting stock for each is high. Chilliwack was noted for its particularly firm, high-quality fruit, and Comox was noted for its exceptionally high yield. Two new selections, 80-26-50 and 80-28-53, are now being propagated for extensive growers' trials. Both are from the cross of Nootka and Glen Prosen and are high yielding and produce firm fruit comparable to Glen Prosen. The quality and size combined with a long harvest season makes 80-28-53 a prime candidate for the fresh market. The other selection appears particularly well suited to machine harvesting.

Strawberry. The new cultivar Sumas performed well in 1987 and is now being widely planted in the Pacific Northwest. Advanced selection 76-7-20 is still being widely tested for its fresh market potential and two more similar selections, BC 76-26-4 and BC 76-26-14, are being microprogated for wide-scale testing.

ENTOMOLOGY

Vectors

Aphid survey. New records brought the number of known aphid species in British Columbia to 392. Aphids have now been collected from 919 different host plants and the total number of aphid–host plant associations is 1764.

Spread of virus diseases. Winged aphids were monitored at a representative location in the Fraser Valley to assist potato inspectors of the Agricultural Inspection Directorate set top kill dates for seed potatoes in the Fraser Valley.

Three strawberry fields were sampled weekly to develop a sequential sampling program for aphids for use in an integrated pest management program for strawberries. Sequential sampling will facilitate scheduling of sprays to minimize spread of virus diseases by aphids.

Pest management

Ermine moth (Yponomeuta malinellus). More than 5000 adults of the parasitic wasp *Ageniaspis fuscicollis* from Germany were liberated in Langley and on Galiano Island. The releases begin a biological control program to reduce the numbers of the European apple ermine moth in the Fraser Valley. The presence of this pest has resulted in quarantine restrictions and mandatory fumigations of apple stocks from nurseries in southwestern British Columbia.

Twospotted spider mite. A management program for *Tetranychus urticae* on strawberries was developed by linking a rapid sampling method with population growth-rate data and information on yield reductions at given densities of *T. urticae*. The program was used commercially during 1987. The sampling accurately estimated densities of *T. urticae* when they infested more than 10% of the leaflets. Below that level the speed of sampling increased but mite densities were underestimated. This bias did not affect management decisions. More than half of the 12 growers involved decreased their miticide usage by 50% from previous years.

A collection of 123 clones of *Fragaria chiloensis*, obtained along the coast of British Columbia, was tested for susceptibility to *T. urticae*. No differences in susceptibility were detected between clones. However, there was a significant correlation between the number of nonglandular hairs–unit area and the fecundity of *T. urticae*, and significant differences were detected between clones with respect to the number of nonglandular hairs–unit area. Further work is necessary before useful clones can be selected for breeding programs.

Cranberry pests. Pherocon 1 CP traps baited with pheromones were effective in monitoring peak flights of both cranberry girdler and blackheaded fireworm moths and assisted commercial growers in timing spray applications. In cooperation with PheroTech Inc., bubble cap dispensers containing 60 or 120 mg fireworm pheromone were evaluated for mating suppression. The lower 60 mg rate reduced fireworm mating by 80% in small plot areas.

Methods for the control of the subterranean larvae of cranberry girdler during the blossom period have been difficult to develop. Applications of diazinon 5G (active ingredient (a.i.) at 3.36 and 6.72 kg/ha), lorsban 15G (a.i. at 1.68 and 3.36 kg/ha), and diazinon 14G (a.i. at 3.36 kg/ha) were evaluated for efficacy. Both rates of lorsban were effective. Only the diazinon 5G a.i. rate of 6.72 kg/ha reduced larvae numbers. Three species of entomogenous nematodes (*Heterorhabditis heliothidis*, *Heterorhabditis* sp. (HP 88), and *Neoaplectana carpocapsae*) were tested for girdler larval numbers.

Virus survey. The second of a 4-year survey for PLRV (potato leaf roll virus) and BWYV (beet western yellows virus) was conducted in commercial potato fields in the lower Fraser Valley of British Columbia. Approximately 10 000 potato plants from commercial fields were sampled early in the growing season and just before top kill for virus determination, using ELISA. Levels of PLRV increased only slightly between the two samples, and all fields sampled had less than 1% PLRV infection. This suggests that the threat of PLRV has diminished considerably for growers of table grade potatoes in this area. BWYV was seldom found in the potatoes sampled.

Onion pests. A computer program, or expert system, has been developed to enhance the decision-making capabilities of integrated pest management consultants working with insect pests of onion. The system accepts field-collected data on onion maggots, *Delia antiqua*, and thrips, *Thrips tabaci*, and prints comprehensive recommendations. The program saves considerable time in formulating recommendations, and greatly improves the comprehensiveness and quality of information relayed to growers compared to past recommendation schemes.

Several granular and drench-applied insecticides were evaluated at two rates for efficacy and longevity against first generation onion maggots in a muck soil. Results were promising this year, with some insecticides providing longer-lasting control than others, and some commonly used insecticides providing no control. This work will assist growers in selecting granular materials more effectively in the future, and will assist in the decision-making capabilities of the expert system.

Potato pests. Several granular insecticides were evaluated for efficacy and longevity against tuber flea beetles, *Epitrix tuberis*, and the green peach aphid, *Myzus persicae*. The insecticides were tested at three locations with differing soil types with different rates in seed furrows. Only insecticides with systemic properties controlled both pests. Temik (aldicarb) and Thimet (phorate) gave excellent control of *E. tuberis* and *M. persicae* in soils with low organic matter. Efficacy of these chemicals was significantly reduced in soil with high organic content. Counter (terbufos) and Lance (cloethocarb), currently unregistered for potatoes, provided excellent control of *E. tuberis*.

Residue chemistry

Hydrolysis of vinclozolin. Vinclozolin, the active ingredient of the fungicide Ronilan 50 WP, hydrolyzes to yield three degradation products: 3,5-dichloroaniline, 2-[(3,5-dichlorphenyl)carbamoyl] oxy-2-methyl-3-butenoic acid, and *N*-3,5-dichlorophenyl-2-hydroxy-2-methylbut-3-enamide. Both the butenoic acid and the enamide were nontoxic to pathogenic fungi.

The disappearance of vinclozolin followed simple pseudo-first order kinetics from pH 4.5 to 8.3. Vinclozolin was much more susceptible to hydrolysis at basic than at acidic pH. Using the Arrhenius plot, the energy of activation for hydrolysis of vinclozolin at pH 7.0 was calculated to be 97.2 kJ/mol. Based on the kinetic data a degradation pathway was proposed.

Residue of oxydemeton-methyl in strawberry. Metasystox-R 2.4 SC (24% oxydemeton-methyl) was evaluated for control of strawberry aphid, *Chaetosiphon fragefolii*, as an alternative to systox. The insecticide was applied three times at a.i. rates of 0.14, 0.28, and 0.56 kg/470 L of water per hectare. Fruit was analyzed 26 and 33 days after the last spray. Residues were below the level of 0.1 ppm, indicating that metasystox-R is an acceptable alternative to systox for control of strawberry aphid.

Residues of chlorpyrifos and diazinon in cranberry. Lorsban 15G (15% chlorpyrifos) at a.i. rates of 1.68 and 3.36 kg/ha, diazinon 5G (5% diazinon) at an a.i. rate of 6.72 kg/ha, and diazinon 14G (14% diazinon) at an a.i. rate of 3.36 kg/ha were applied twice for control of cranberry girdler, *Chrysoteuchia topiaria*. Fifty-nine days after the second application, fruit samples were collected for residue analysis. No detectable residues were found in any of the diazinon-treated cranberries. In cranberries treated with lorsban at a.i. rates of 1.68 and 3.36 kg/ha, residues of 0.058 and 0.084 ppm of chlorpyrifos were detected, respectively. These results indicate that lorsban 15G at a.i. rates of 1.68 and 3.36 kg/ha is highly promising for control of cranberry girdler larvae.

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